JOURNAL OF

Petroleum Technology

Volume 1 OCTOBER, 1949 Number 10

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This is the first in a series of interpreted electrical logs from identified formations and fields which Schlumberger will reproduce in this publication. If you would like to keep this entire series, please write to us on your letterhead and we will be glad to send you a reprint of this log and a binder in which you may file subsequent logs as they are published. This series is made possible through the courtesy and cooperation of the oil operators who have released these logs.

LOG ANALYSIS

1) Water saturation S

$R_O = 0.4$ ohm in "X". This value will be used for "B" and "C" sands calculations.

In "B" Sand: $S = \sqrt{\frac{0.4}{29}} = 12\%$ approx.

In "C" Sand: $S = \sqrt{\frac{0.4}{12.5}} = 18\%$ approx.

2) Formation water resistivity R_w

$SP = -90 \log_{10} \frac{R_m}{R_w}$

At water level, in "X", SP = −115 mv.
thus, $R_w = 0.04$ ohm BHT

3) Porosity p

$F = \frac{R_o}{R_w} = \frac{0.4}{0.04} = 10$

$p = \sqrt[m]{\frac{1}{F}} = 28\%$ for $m = 1.8$

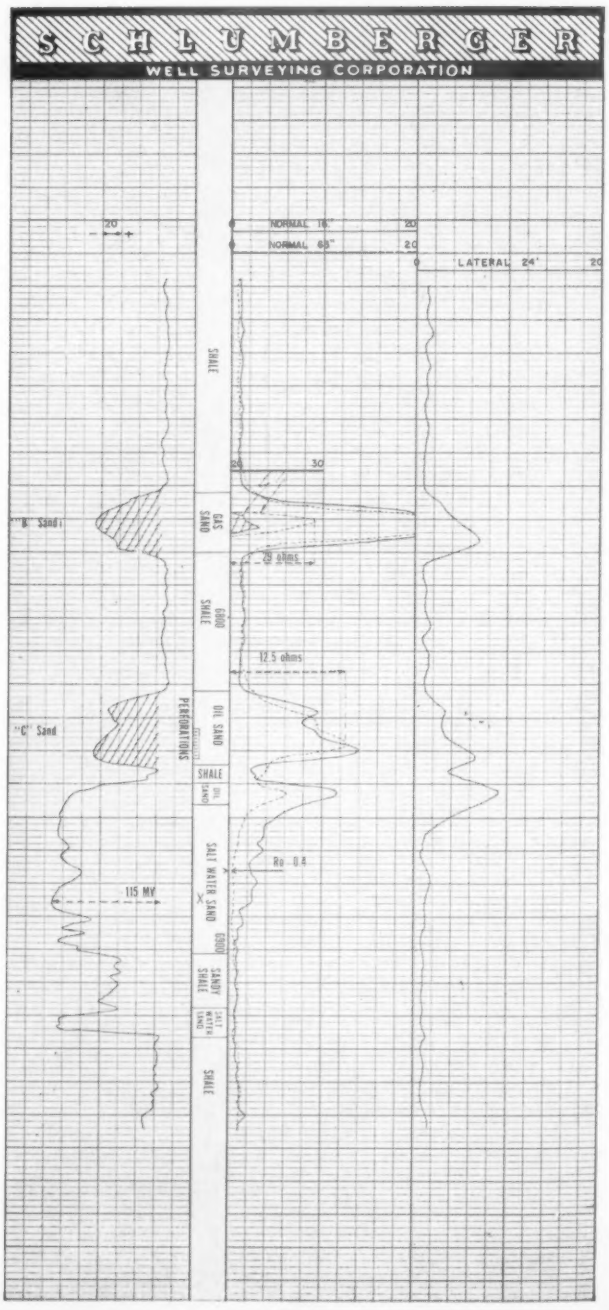
CORE ANALYSIS

B Sand	Porosity	30%
	Permeability	800 md.
	Residual Water	43%
C Sand	Porosity	30%
	Permeability	800 md.
	Residual Water	42%

PRODUCTION RESULTS

Perforated: 6833-42 with 24 shots
Potential: 140 bbl. oil 28.3° API
Gas oil ratio 758/1

SCHLUMBERGER
WELL SURVEYING CORP.
HOUSTON, TEXAS



Guest Editorial

by

HOWARD C. PYLE, Member AIME

President, Continental Consolidated Corp.

Los Angeles, California

DIRECTIONAL DRILLING— FROM TRESPASS TO TECHNIQUE

TWENTY years ago Frederic H. Lahee wrote that the problem of crooked holes ranked second only to overproduction in the minds of the exploration and production elements of the petroleum industry. He said, "To some this may sound like a gross exaggeration, or like a fall from the sublime to the ridiculous; but when we consider how many holes have been drilled off the vertical, and where such is the case, what large sums of money have been lost in drilling operations, in producing operations, in false or inadequate geological interpretations, and in erroneous technical deductions based on assumed well spacing — when we consider the almost endless ramifications of these opportunities for loss, we can better appreciate the significance of this problem."

Development and production men in California have enjoyed many visits from their counterparts in other sections of the country, and a subject of common discussion has very often been controlled directional drilling. This youthful drilling technique has matured rapidly and serves a useful purpose today, but it had an illegitimate beginning which some PETROLEUM TECHNOLOGY readers will recall.

IN 1929, Alexander Anderson published an article summarizing results obtained in surveying 2 million feet of rotary hole, about 70 per cent of which was in the Signal Hill field of California. He showed that at 5,000-foot depth the average deviation of over 100 wells was 16° or 400 feet from the vertical. Maximum deviation was 52° or 1,750 feet.

As methods of surveying crooked holes were developed and perfected, great attention was given to drilling straight holes. Attention was also given to controlling the inclination and direction of crooked holes. As early as 1925, a directional well was drilled and completed at a predetermined non-vertical location. Development of controlled directional drilling lagged following this first well because of difficulty in quickly determining the current bottom hole position of the well. In the early 1930's "single-shot" instruments were developed, thus simplifying well surveying and making it relatively inexpensive. The practice of controlled directional drilling flourished as a result. The offshore portion of the Huntington Beach oil field was quickly developed thereafter with wells averaging 4,500 feet deep being bottomed 1,500 feet from the vertical.

AN epidemic of directional wells drilled from poor or edge locations followed, and the industry soon realized that something would have to be done about subsurface trespass. There was unusual activity at Signal Hill. The Shell Oil Co., Union Oil Co., The Texas Co., and a number of other companies joined together, conducted a special and secret investigation, and concluded that many wells were producing or being drilled to produce oil from "up structure" leases. Based on these conclusions 40 lawsuits were filed, each embracing a single well. In due course every one of these wells was either enjoined from further production or plugged back to the point of trespass. Permanent injunctions with the right to make a subsurface survey of an alleged trespassing well was proved proper remedy to prevent threatened or continuing trespass.

In subsequent years there was continued improvement in the technique of drilling controlled directional wells. New tools and new techniques were developed and incorporated into routine drilling procedures. Ten years ago directional wells were drilled with complete dependence on deflection tools and it was not unusual to use 15 or 20 settings in a single well. This made well costs high and left many sharp turns or dog-legs in the finished well course. Today, primary control is still affected with deflection tools; however, continued dependence on these tools is unnecessary as the desired results can be obtained by proper manipulation of drill pipe, pumps and selection of drilling tool assemblies. For example, 5,500-foot wells have been repeatedly drilled and bottomed at predeterfined locations 4,000 feet horizontally from the well head with but a single placing of a deflection tool. Angle changes in such a hole are well integrated and the well course is free from dog-legs.

TEN years ago directional holes cost substantially more than did straight holes. Today, on a footage basis, there is little difference. One must remember, however, that the footage drilled in a directional well may be very substantially greater than would be the footage of a vertical well drilled to the same objective. A contributing factor to the low cost of directional wells is that today they are usually drilled from restricted areas where drilling rig moving costs are at a minimum, where oil and gas gathering lines are short and where there are other economies incident to having well heads in close proximity.

Oil field development by directionally drilled wells has become commonplace in California. In 20 short years the industry has perfected a new technique and learned how to control its use legally so that it could be put to work for the industry. ★ ★ ★

When Do We Need A Synthetic Fuel Industry?

A. L. SOLLIDAY, Executive Vice President
Stanolind Oil and Gas Company

Coal and oil shale will eventually supplant crude petroleum as the major raw material for gasoline, diesel fuels and burning oils. This fact is so generally accepted that it finds little argument. But agreement about the future of synthetic fuels ends at that point.

Controversies exist on two important problems — (1) When will a synthetic fuel industry be justified, either by economics or by necessity, and (2) What course should the nation and the industry follow in preparing for the advent of synthetic fuels?

In a normal economy with a plentiful supply of petroleum like we have today, liquid fuels from coal and oil shale will appear only when they can compete with products from petroleum. On the other hand, when a plentiful supply of oil no longer exists, sufficient economic adjustments will occur to make a synthetic industry possible.

Synthetic fuels from coal and oil shale cannot compete in today's market. Inasmuch as they are not now economical, recent proposals have recommended that the government subsidize a synthetic fuel program. The proponents of such a policy state that such a program is justified as a security measure.

After thorough study, we believe that the nation should *not* enter into a synthetic fuel construction program now. The nation is in no danger of a liquid fuel shortage in the near future. As a matter of fact, supplies of oil will probably be great enough to make such a program unnecessary for at least another 10 years. Even in the case of war, supplies of liquid fuels should be adequate without turning to coal or oil shale before 1961.

Stanolind Oil and Gas Co. recently completed an analysis of the current competitive position of liquid fuels from coal and oil shale as compared to those from oil and gas. The background for this analysis has included several years' extensive work on synthetic fuels at Stanolind's laboratories where considerable experience was gained in connection with designing the Hugoton gas synthesis plant, a project which was later suspended.

The results of Stanolind's analysis have been published in a paper, *Liquid Fuels from Coal and Oil Shale*, which appeared in the September issue of the JOURNAL OF PETROLEUM TECHNOLOGY.

Stanolind's studies together with a thorough survey of all available information show that the production of liquid fuels from natural gas, coal and oil shale is technically feasible. The technology of synthesis from natural gas is already highly developed. As a matter of fact, a commercial synthesis plant of this type is now nearing completion at Brownsville, Texas. However, technical progress on synthesis of coal and oil shale has not advanced as far. These processes still remain in an immature state of development.

Studies of cost, also reported in that article, show that liquid fuels from coal and shale cannot compete successfully with products from petroleum in today's market. Fig. 1 shows the direct costs of products from coal and oil shale, as compared to those from oil and gas. These costs were based on processes considered to be technically feasible today. They include costs of mining, manufacture and transportation, and the *direct* costs of making a gallon of gasoline from these raw materials are not far different.

However, direct costs alone do not provide a true basis for comparison. To do so, it is necessary to include charges for depreciation and profit. A reasonable return on investment would be 14 per cent a year. This return would take care of depreciation and allow an income after taxes sufficient to pay off the investment in 10 years. In plants of this type, with such a high obsolescence factor at this stage of development, a 10-year payout period would certainly not be unreasonable. When these investment charges are added to direct costs, the total costs of liquid fuels vary considerably. On this basis, gasoline from crude would cost 12.2 cents per gallon, and that from natural gas would be 15.0 cents. But costs for oil shale and bituminous coal would rise to 22.5 cents a gallon, while that from sub-bituminous coal would go up to 27.6 cents.

These figures include transportation costs to a common marketing area. If a plant using natural gas were more favorably located to its market, much of the difference in cost between crude and natural gas would be eliminated. However, even lower transportation charges cannot greatly affect the cost position of gasoline made from coal or oil shale.

The final cost to the consumer would be still higher. The motoring public now pays an average of about 15 cents per gallon above manufacturing costs. This 15 cents covers such additional costs as state and federal taxes, profit for dealers,

tank wagon distribution and so on. Thus, retail prices for gasoline from coal and oil shale would be as much as 40 or 45 cents a gallon.

Recently the Bureau of mines has made many statements with regard to synthetic fuels. These newspaper reports have included many cost items, ranging from the cost of shale mining to the cost of a 10-million-barrel-per-day synthetic industry. Most of this Bureau of Mines information, as reported in the press, does not indicate what cost items have been included and what ones have been left out. Nor do these reports indicate the basis for figures quoted.

For example, the Bureau of Mines recently stated that crude shale oil could be produced at a cost of $2.25 to $2.50 a barrel. The public would assume from this that crude shale oil would be competitive with petroleum. Such is not the case. The costs of manufacturing finished products from crude shale oil are materially higher than the costs of manufacturing finished products from crude petroleum. We feel that, in their present form, the Bureau's statements are misleading. The resulting confusion could be largely eliminated if the Bureau would more thoroughly explain how it arrived at its cost figures.

Accepting Stanolind's evaluations as the present economic status, it is immediately apparent that a synthetic industry is far from being competitive today. While our figures show that direct costs are not greatly out of line, the addition of investment charges makes synthetics decidedly uneconomic. Only if the government furnished all the capital necessary would it be possible to enter into a commercial synthetic fuel program now. If such a course is taken, the cost to the taxpaying public would be huge.

Barring subsidies, however, these fuels will become realities only when petroleum can no longer supply the nation's total demand for liquid fuels, or when developments reduce costs to competitive levels. Let us first consider the question of future requirements for liquid fuels and then take up the question of supplies that may be available to meet those demands. When this has been done, we will be in a better position to estimate when we will need a synthetic industry.

A forecast of our future demands involves a long-range analysis. This can be done by considering certain significant trends in our economy. These major trends include the growth

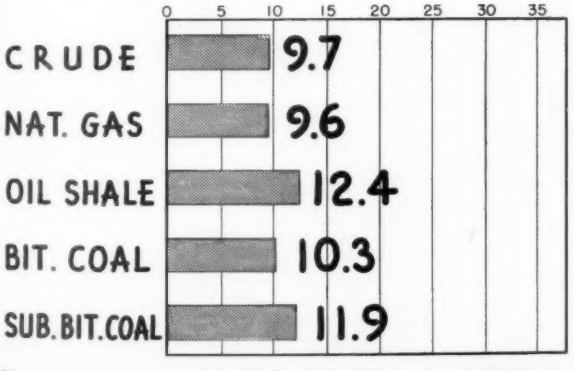


Fig. 1 — Direct costs of liquid fuels in cents per gallon from sources shown.

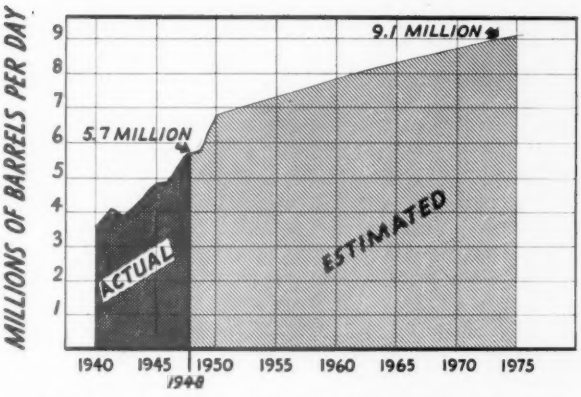


Fig. 2 — Total U. S. daily demand for petroleum.

of our population, the increasing use of automobiles, trucks, buses and other motor vehicles, our rising standard of living and the decentralization of cities and industries.

From these trends we can estimate the increase in the number of motor vehicles between now and 1975. But such an estimate by itself is not enough to reveal probable gasoline consumption. Other factors must be included. While the average mileage per car will continue to increase, more efficient motors will tend to keep gasoline consumption per car from rising much above today's level. The combination of many such factors determines the demand for motor gasoline in the automotive field. In a like maner, consumption of gasoline in other uses such as aviation and farming may also be estimated.

From these calculations, total gasoline demands during the next quarter century are estimated to reach 1,100,000 barrels per day above present rates.

Using various forecasting methods, we can also estimate the consumption of other fuels and lubricants for airplanes, tractors, locomotives, miscellaneous light-duty power equipment and heavy-duty machinery. Likewise, we can predict future needs for domestic and industrial heating fuels, greases, waxes, and other petroleum products.

When all these requirements are totaled, the demand shown in Fig. 2 results. By 1965 the nation will require 8,400,000 barrels of petroleum per day. By 1975 that demand will reach 9,100,000 barrels per day.

Various companies in the oil industry make forecasts extending far into the future. Only rarely is such a forecast published. The only other published forecast of total demand extended to 1975 which has come to our attention was made last May by the Bureau of Mines. The Bureau estimates that demand for oil in 1975 will be from 12,7000,000 barrels to 16,400,000 barrels per day — or 2 to 2½ times the present demand.

The Bureau's figures appear far too high. We can hardly expect demand to keep going up at an increasing rate over such a long period. To reach such levels we must assume every use of petroleum will more than double, or that radically new uses will be found. Actually, the nation will reach

the saturation point in many petroleum uses before that time. For instance, passenger cars will not double between now and 1975, even if the population reaches the largest estimate forecast by the Census Bureau. In addition, some other uses are already nearing a saturation point. For example, the nation now has one tractor for every 105 acres of tillable land. In view of considerations like these, we do not believe that demands for oil can rise as rapidly as the Bureau of Mines predicts.

If the nation's demand will rise to over 9,000,000 barrels a day, as our forecasts show, how can these needs be supplied? These requirements can be filled in two ways: by crude petroleum, both domestic and foreign, and, when necessary, by synthetics from other raw materials.

For the immediate future at least, domestic petroleum will serve as the nation's major supply. This production will come from five sources — from existing wells, from the development of known but undrilled reserves, from future onshore discoveries, from future offshore discoveries and from secondary recovery.

Production from the first of these domestic sources — existing wells — is declining at a regular rate. This type of decline has been characteristic of the average oil well for the past 25 years. On this basis, present active wells will produce another 28 billion barrels of oil by primary recovery. This estimate agrees quite well with that of the American Petroleum Institute, which predicted these reserves at 26.8 billion barrels as of January 1, 1949. The rate at which these existing wells will be produced is shown in Fig. 3. The top line is of course the total demand curve, while the lower, shaded portion of the illustration represents production from wells now in operation. The abnormal rates of production decline occur because we expect that curtailed market demands will continue for about six more years.

The next domestic source — known but undeveloped reserves — are expected to add another 10 billion barrels to the nation's ultimate recovery. These reserves will increase future supplies as indicated by the additional area in the illustration.

Next, future onshore discoveries can be estimated by correlating exploratory effort and cumulative oil discoveries. This correlation shows that in spite of technical progress, the industry's degree of success in wildcatting has declined through the years. New reserves discovered have been progressively smaller. Considering these factors, it is estimated that new onshore discoveries will increase our supply by 35 billion barrels. The rate at which this oil will be produced after it is discovered is the third addition to our supply curve.

Added together, the total remaining onshore reserves which we can recover by primary methods equals 73 billion barrels. Thus, our total ultimate primary recovery onshore is expected to be 110 billion barrels. Other methods of estimating these reserves yields results which do not vary substantially from this 110-billion-barrel figure.

Now, let us consider offshore reserves. Production estimates from submerged coastal lands are difficult to make at this stage of development. By analyzing recoverable reserves on adjacent shore areas, however, it is possible to evaluate the oil-producing potential of offshore structures. We expect that 20 billion barrels can be recovered from the continental shelf. The rate at which the industry can produce from offshore reserves will depend to a great extent on how soon the question of titles to offshore leases can be settled. The rate indicated here assumes that this issue will be settled in the next two years.

Finally, production in the United States should include the oil which can be obtained by secondary recovery methods. Secondary recovery as used here is the oil recovered by supplying energy to the reservoir from external sources and represents production which could not be recovered unless external energy is supplied. Present day secondary recovery reserves have been estimated by the Interstate Oil Compact Commission to be approximately 8 billion barrels. In the future, secondary recovery measures will be applied to fields not now included in this figure, and additional production will be secured. As time goes on, these techniques will be applied immediately in the development of new fields under sound engineering practice. We have chosen to call the extra oil produced by all such practices, secondary recovery. Altogether, we estimate that secondary recovery should add 20 billion barrels to the nation's supply. This forecast is based only on methods in practice today.

From the five domestic sources, therefore, total ultimate crude production in the United States, onshore and offshore, is estimated to be 150 billion barrels, as shown in Fig. 4. Of this total, 37 billion barrels have already been produced.

So far, our estimates show that during the next decade, future domestic production will begin to fall short of meeting our growing requirements. American oil production will reach a maximum rate of 7,100,000 barrels a day by 1958. It will drop to a rate of about 6,000,000 barrels in 1965, then taper off to 4,700,000 barrels a day by 1975.

A large part of these deficits can be filled by imports from the Western Hemisphere. To estimate how large these imports will be, we analyzed the supply and demand for Canada, Central and South America, using techniques similar to those employed for the United States. These areas will continue to produce more crude than they will use, and we can assume that their growing surpluses can be exported to the United States. Consequently, we estimate that the United States can

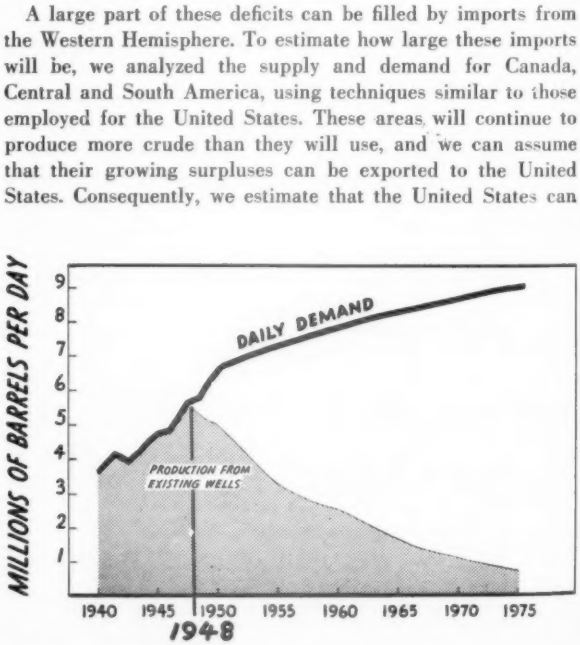


Fig. 3 — Comparison of production from existing wells from estimated demand.

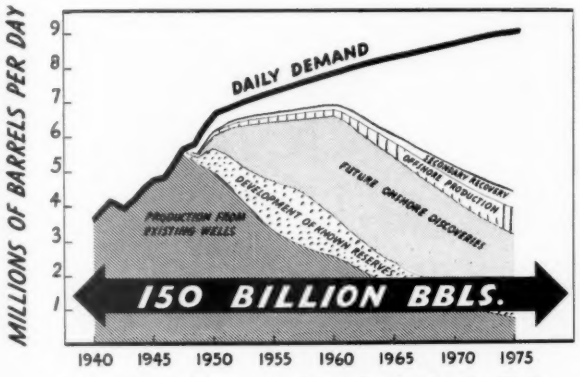


Fig. 4 — Total ultimate crude production in the U. S.

increase its imports from the rest of this hemisphere from about 500,000 barrels a day in 1950 to 830,000 barerls in 1960 and 2,900,000 barrels in 1975. Thus, domestic production plus these imports can supply all of our demands for oil for at least another 10 years.

A small import of crude is now coming from the Eastern Hemisphere and it will probably continue at this low level through 1960. After that time, all demands which cannot be filled by domestic and Western Hemisphere production could be supplied indefinitely from the Eastern Hemisphere.

In the interests of nation or hemispheric security, the government may limit imports from that zone. Such a limit is assumed to be approximately 250,000 barrels a day, a quantity which represents a relatively small fraction of the national supply. In the event that these small imports were suddenly cut off, the economy of this country would not be seriously injured. A minor curtailment of civilian consumption could easily offset this loss.

When imports from the Eastern Hemisphere are combined with all other supplies, all needs for oil are filled until 1961, but after that time a growing gap between supply and demand becomes evident, as shown in Fig. 5. By 1965, that deficit will be 420,000 barrels a day and will increase to 1,260,000 barrels by 1975. On the basis of these forecasts, it now seems plain that the nation has at least until 1961 before it needs to turn to coal and oil shale to supply any of our liquid fuel demands. There is nothing, therefore, to indicate that we should begin the construction of synthetic fuel plants immediately.

Before turning to other phases of the supply and demand problem, it should be pointed out that all estimates presented here have been developed on what is believed to be a conservative basis. In so doing, we have kept our forecast of production to the lowest level possible. If future supplies actually prove to be greater than we think, if the nation is actually more successful in finding new oil reserves than we now estimate, or if greater recovery can result from methods still undiscovered, the necessity for synthetic fuels would be postponed beyond our forecast date of 1961.

Certainly, the importance of work to improve and develop new recovery methods cannot be over-emphasized. For, if research can increase oil recovery by as little as a few percentage points, ultimate recovery will be considerably larger than the 150 billion barrels which we believe possible under present methods.

While we have chosen to take the least optimistic view of future supplies, we have done the opposite in the case of future demand. The demand estimates have been kept on the high side. Later on, if the oil requirements of the American public actually prove to be less than we estimate, crude could supply our needs for a longer time, and synthetics could be deferred beyond 1961.

The foregoing discussion covers only the normal peacetime side of the supply problem. However, the possibility of some national emergency between now and 1961 should also be considered. Estimates of wartime petroleum needs differ widely. But even if demands reach the highest estimates that have been publicized, the demands of the armed services can be met in whole or in large part by curtailing civilian uses. This is particularly true if our peacetime petroleum economy continues to grow, as all signs indicate that it will. The enlarged producing and refining capacities necessary to meet these growing needs will automatically create a larger supply pool from which emergency stocks could be diverted. But if a national emergency would prove to be so acute that we could not supply military needs through rationing, these stocks could then be supplied by at least three other methods: (1) additional capacity in producing and transportation as well as refining facilities; (2) stockpiles of critical products, such as alkylate or toluene; or (3) synthetic fuel plants.

Recent discoveries in Canada and curtailed production in this country indicate that it should be possible to maintain excess crude producing capacity, at least for the immediate future. Similar excess capacity served us well in the last war. Additional refining capacity would call for a heavy investment, but this would cost less than would synthetic fuel plants. The technology of refining has reached such an advanced state of development that refineries would not be out-dated in a 5 or 10-year period. In contrast, the technology of synthesis from coal and shale is in such an early stage of development that synthetic fuel plants would rapidly become obsolete.

So, in an emergency, oil requirements can best be filled, first by rationing, and second, *if necessary*, by building excess refining, transportation and producing capacity. Stockpiles of critical materials represent additional steps toward preparedness. Together, these measures should meet any crises for oil in the immediate future. Consequently, even for emergency reasons, a synthetic fuel industry would represent a costly expedient for at least another decade.

Still another important consideration should postpone a synthetic plant construction program. From what we know about the current technology of synthetic fuels from coal and shale, we recognize that research can greatly improve present designs. Research can lower the prohibitive costs which now prevail and, by so doing, put today's designs into an outmoded category. As instruments for research, full-scale plants or so-called "demonstration" plants are at best clumsy tools. Industry knows from experience how much it costs to make significant changes in a commercial plant. The building of such plants can only prove the workability of one specific design. On the other hand, a flexible pilot plant, costing but a fraction of a commercial plant, can furnish us with design

data easily and efficiently. Each phase of the process can be varied to solve whatever problems may arise.

Obviously, the nation has much to gain if we are not forced to freeze our designs as long as development is at its present immature level. Work is now going forward on many improvements in design of coal synthesis plants. If research can perfect only those improvements which have an even chance of success, the costs of making gasoline synthetically from bituminous coal can be reduced from 22½ cents per gallon to 17 cents. This 5½-cent reduction would go a long way toward making the process competitive. In passing, it should be noted that the gap between synthetic and crude will be narrowed still further if crude prices rise gradually as we expect them to.

As long as synthetic fuels are more expensive than products from crude, there will probably be proposals to support a synthetic industry with government subsidies. Perhaps the general public does not appreciate the staggering costs involved. Our estimates indicate that investment per daily barrel of gasoline from bituminous coal would be $13,900. A daily capacity of a million barrels would cost the public almost 14 billion dollars, or about $100 for every person in the country. Even in today's multi-billion dollar budgets, this is an enormous sum. In the end, the general public would have to pay that sum through increased taxes.

Government subsidies also have other detrimental effects. Such doles encourage the retention of uneconomic practices by removing the incentives for competitive development. Thus, by discouraging initiative, subsidies could actually postpone the development of lower-cost techniques. The danger of this is apparent. If competitive development is retarded, the technology of synthetic fuels will not advance as rapidly as it should. Thus, when the time for synthetic fuels finally arrives, the nation will not be in as good a technological position as it might have been.

So, let me summarize. The national economy does not require synthetic production for at least another 10 years, even in the case of war. We should use the time between now and 1961 to advance the technology of synthetic fuels to a more mature state of development. We can do this by intensifying research on laboratory and pilot plant scales to improve present processes. By so doing, synthetic fuel plants can be made more efficient; investment costs can be lowered. Furthermore, the oil industry can accomplish these aims *without government subsidy*.

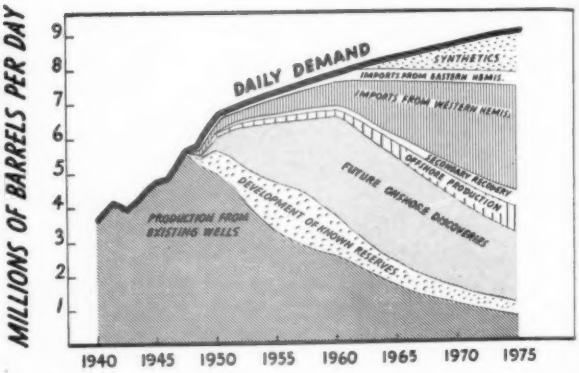


Fig. 5 — Total production, imports, and synthetic manufacture.

While government participation in the research work is advisable and should probably be increased, the building of "demonstration" or commercial plants would not only be undesirable but would also be extremely costly to the public. Finally, the petroleum industry has demonstrated its ability to meet the many problems that it has faced in the past. This successful record guarantees that it can also establish a synthetic fuel industry rapidly and efficiently — and at the proper time. ★ ★ ★

Employment Notices

The JOURNAL will post notices of men and jobs available. Companies and AIME members are invited to use this space, for which there is no charge. Except as noted below, address replies to: Code (appropriate number), JOURNAL OF PETROLEUM TECHNOLOGY, 601 Continental Building, Dallas 1. Show return address on envelope. These replies will be forwarded unopened, and no fees are involved.

Replies to the personnel coded M-472, and positions Y-1497(b), Y-2415, Y-2685(a) and Y-2685(b) below should be addressed to: Engineering Societies Personnel Service, 8 West 40th Street, New York 18, N. Y. The ESPS, on whose behalf these notices are published here, collects a fee from applicants actually placed.

PERSONNEL

♦ Graduate petroleum engineer, 33, married, currently doing administrative petroleum engineering on various phases of drilling and production for large company. Desires position with good opportunity with well established oil company or associated industry. Prefer to locate in East but will consider any location. M-472.

♦ Petroleum engineer with geology degree wants to locate a new connection, preferably with a major company in the Mid-Continent area. Will accept an assignment in the Rocky Mountain area. Have supervised the drilling and completion of several hundred wells from Kansas to the Louisiana Gulf area. Have had several years experience as a valuation and reserve engineer in division office. Have also planned and executed several successful water floods. Code 108.

♦ Graduate civil engineer desires new connection with drilling contractor or oil company. Interested primarily in position which offers experience in drilling operations. Over three years varied experience with major oil company in Gulf Coast region in construction and production work. Location immaterial and will consider foreign assignment. Code 110.

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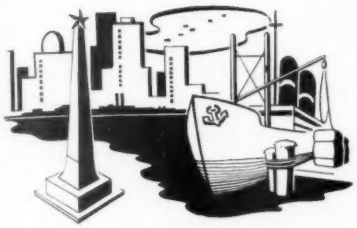


Gulf Coast Section Activities

By J. E. Kastrop

The first meeting in the fall season was held September 20 at the Houston Y.M.C.A. where 115 members and guests gathered to renew acquaintances and learn more about the tidelands situation. Owen Thornton, chairman, presided, and introduced the matter of a study group to be sponsored by the Section. J. S. Levine, research chemist, Shell Oil Co. Exploration and Research Laboratory, was appointed to organize and manage the study group. He will be assisted by W. R. Purcell, research chemist at the Shell Laboratory. The organizational meeting of the study group will be held at the Shell Laboratory conference room the evening of October 24. A canvass of the membership indicated that there was a stronger interest in reservoir engineering than any one other subject, and therefore, the first group will concentrate on the many phases of this topic. These study groups are designed to be of the discussion type without reaching any definite conclusions or recommendations on any particular phase.

George Gray, Baroid Sales, representing the Section on the Engineers Council of Houston, reported that the other engineering societies were making a canvass of their membership to determine how many would be interested in doing outside graduate work which would result in awarding of master's or doctor's degree in engineering. If there is sufficient interest shown in this program, an effort will be made by the engineers' council to get an accredited college or university to sponsor such graduate courses. A post card canvass will be made of the Section members to determine what interest they might have in such a program.

E. L. Petre, chairman of the program committee, introduced A. W. Bounds, division attorney, Stanolind Oil and Gas Co., who spoke on the subject, "Legal and Political History of the Tidelands Controversy". The legal history of the open waters (not inland waters) is relatively short. There has been mention made of the three-mile limit, 12-mile limit and even the 27-mile limit. The 12-mile limit was used in the days of prohibition and hasn't been applied since. The three-mile limitation was tendered in international law which has been universally recognized. It provides that the jurisdiction of any country extends seaward from shore for a distance of three miles. The three-mile limit had no previous significance to ownership of land below this belt of water. It was largely a political figure and was based on the distance offshore within which a nation could effectively defend itself. It was the range of early cannons. However, this conception has been injected into and is a factor in the legal fight in the Tidelands Case.

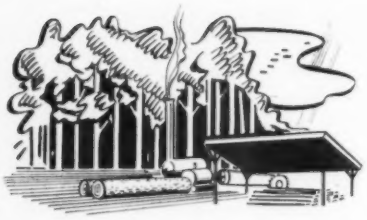
In the California Case, the U. S. Government filed suit to claim ownership of the submerged lands below the water extending from low tide out to the three-mile belt. There is no justification in the law books for this contention. Legal cases involving water bottoms are numerous, but these deal with inland waters not a part of the open sea. The U. S. Supreme Court has held on many occasions that inland waters were the property of the bounding states, and this ownership of such lands came about as a part of admission to the Union. This was the defense of California in its fight against the Federal Government.

The tidelands controversy was first agitated during Congressional hearings

Continued on page 17

Lt. Col. Merton Singer (left), USA, Armed Services Petroleum Board, Hawaii, discusses the oil situation with Bob Laird, department of petroleum engineering, A.&M. College of Texas.

A. W. Bounds, division attorney, Stanolind Oil and Gas Co., Houston, was the principal speaker at the Gulf Coast Section meeting on Sept. 20.



East Texas Section Activities

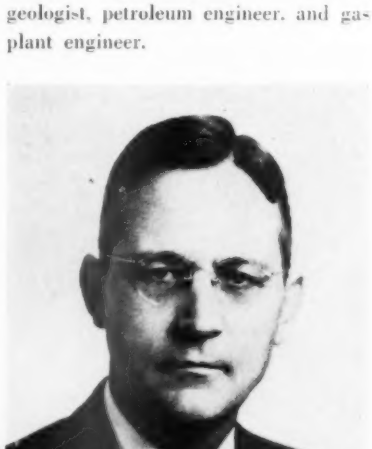
By Peter E. Des Jardins

After a three-month summer vacation, the Section renewed activities with a meeting held in the Blue Room of the Kilgore Hotel on September 13. Following dinner, T. L. Forehand, chairman of the Membership Committee, presented a list of eligible non-members of the AIME who live within the limits of the East Texas Section. He requested anyone who knew these men personally to act as delegates of the membership committee and contact them with regard to applying for membership in the AIME. Chairman Jack M. Shepherd announced the appointment of Peter E. Des Jardins to succeed Roy F. Beery, Jr., as secretary-treasurer of the Section. During the summer Roy Beery left Kilgore to accept a position with Danciger Oil and Ref. Co. in Norman, Oklahoma.

The evening was highlighted by a very timely and informative address on "Unitization and the Voluntary Pooling Law of Texas", presented by Raymond M. Myers, of the legal staff of Magnolia Petroleum Co. Myers first pointed out that previous statutes regarding unitized operations in the State of Texas applied only to gas and had gone no further than to say that such operations did not violate the conservation laws of the state. The new Senate Bill No. 24 provides for a wider variety of unitized operations and also grants such operations some degree of immunity from the anti-trust laws of the state.

Myers then pointed out several provisions of the new voluntary pooling law which require interpretation. First, he brought up the question of what unitization agreements would require Railroad Commission approval. He interpreted the law to mean that all agreements made after the effective date of Senate Bill No. 24 would require approval, while contracts effective prior to that date need not be submitted for approval. The law states that none of its provisions are intended to require Commission approval of voluntary agreements for the joint development and operations of jointly-owned properties. Myers stated that since this provision could conceivably apply to any of the unitized operations provided for in the law, he interprets it to apply only to those agreements generally referred to as joint operating agreements, which usually cover properties of limited area, and provide for the drilling of a well, the joint development of the poperties, and the primary production of oil and gas therefrom.

Repeated stress was given to the fact that in presenting a unitized operating agreement to the Railroad Commission it must be proved that the agreement is necessary for one of the operations provided for in the law. To illustrate the method used in presenting such a case, Myers outlined the testimony which should be presented by a land man, geologist, petroleum engineer, and gas-plant engineer.



Raymond M. Myers, of the legal staff of Magnolia Pet. Co., addressed the East Texas Section on "Unitization and the Voluntary Pooling Law of Texas".

In the presence of a group of engineers, Myers felt that it was unnecessary to mention the advantage of unitization in the fields of economics and conservation. He stated that while Senate Bill No. 24 overcame some of the obstacles in the path of unitized operations, there was still much to be done, and that engineers and lawyers must continue the work of educating the public to a realization of the advantages of unitization.

Following a brief discussion of Myers' talk, Chairman Jack M. Shepherd announced that present plans were for the October meeting to be a joint meeting with the Shreveport Geological Society in Shreveport.

Personals

J. P. SCHMALTZ, formerly district engineer for Magnolia Petroleum Co. at Rodessa, La., has accepted a company scholarship to work toward a master's degree at Univ. of Oklahoma. J. F. MAYFIELD, formerly petroleum engineer with Magnolia at Kilgore, has been transferred to Rodessa to replace Schmaltz. WM. G. SOLE, who received his degree from Univ. of Oklahoma in June has replaced Mayfield with Magnolia in Kilgore.

G. A. CLARK, after completing graduate studies at the Univ. of Texas, has joined the reservoir engineering staff of Ohio Oil Co. in Shreveport.

D. A. WILSON has taken a leave of absence from the Stanolind Oil and Gas Co. engineering staff to accept an A.P.I. Fellowship to work on graduate studies at Univ. of Oklahoma.

L. H. BOND has been transferred from Fort Worth to join Stanolind Oil and Gas Co.'s engineering staff in Longview.

J. W. LARUE, engineer with Stanolind Oil and Gas Co., has accepted a company scholarship to work on graduate studies at Univ. of Oklahoma. ★

Kansas Section Activities

By V. J. Mercier

The fall season was started with a meeting on September 7 in the Lassen Hotel of Wichita, which was attended by 62 members and guests. J. E. Smith of Johnston Oil Field Service Corp. in Houston was principal speaker with a paper on "Drill Stem Testing Procedure in Open Hole".

Chairman V. J. Mercier announced that G. E. Abernathy, vice chairman in Eastern Kansas had moved to Fort Worth with Signal Oil and Gas Co., and that Fred Kluck, Ohio Oil Co. at Eureka, will serve in this post for the remainder of the year. He announced also that Carl Lund, who had been serving as JOURNAL Secretary, had moved to Oklahoma City with the Loeffler Green Supply Co.

A summary of J. E. Smith's paper is as follows:

The formation tester is used to test open holes without the expense and loss of time incurred in setting casing. It relieves the zone being tested of hydrostatic pressure of the drilling fluid in the open hole and subjects the formation to atmospheric pressure through the drill stem. Flow of fluid into the testing tool is controlled by valves.

Experience has demonstrated that hard or firm non-fractured formation, such as sand, shell, lime or chert provide the most effective packer seat. The seat should be based upon the best formation possible, immediately above or preferably in the top of the zone to be tested.

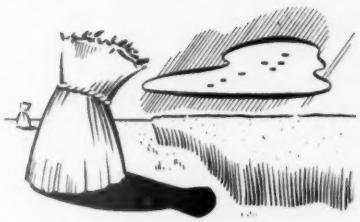
A more conclusive test can usually be obtained by testing small sections of hole. In relatively thin sand sections, the test zone is frequently two to ten feet. When producing zones of greater thickness are encountered, it is then feasible to test more hole per test.

The hole and drilling fluid should be conditioned prior to making a drill stem test. Fully 50 per cent of all test failures are caused by improper conditioning. The hole should be full gauge, as the packer will scrape off sections of the mud sheath and other debris, and this material will plug orifices in the testing tool when they are opened. The drilling fluid must be heavy enough to control the producing zone, and the viscosity low enough to maintain fluidity. Circulation should be maintained for sufficient time to remove all cuttings and heavy mud from the hole which will interfere with fluid moving into the tester.

A fluid cushion for the tester is achieved by filling the drill pipe with water or drilling fluid. This reduces the sudden release of pressure below the packer when the tester is opened, and cushions the entry of formation fluid into the drill pipe. Careful consideration should be given to the amount of fluid cushion used as the interposed fluid has to be lifted by the formation pressure when the testing tool is opened.

The tester consists of four valves — the packer, perforated anchor, and depth pressure recording device, assembled in that order. They are connected to the bottom of the drill pipe, and when the zone to be tested is reached the packer is expanded against the wall of the hole by applying the weight of the drill pipe. When the valves are opened the zone beneath the

J. E. Smith of Johnson Oil Field Service Corp. spoke on drill stem testing at the September 7 meeting.



packer is free to produce under its own pressure, through the drill pipe.

Immediately following the opening of the tester, and during the test period, the fluid level in the annular space should be closely observed, because the fluid level will fall off if the packer is not holding. The drill pipe should be then picked up immediately, and it is advisable to attempt to reset the packer.

When the packer holds the tester is left open for ten to thirty minutes, the shut in valve is then closed, and formation pressure builds up to equilibrium. It is important to allow sufficient time for this pressure build up during the shut in period.

At the conclusion of this period, the drill pipe is picked up to open the equalizing valve which allows the hydrostatic pressure of the mud column to be applied to the formation below the packer. This equalizes the pressure above and below the packer and facilitates its removal from the seat.

The bottom hole pressure gauge is at the bottom of the tester, and measures pressure in psi during the entire testing operation on a sensitized chart.

The speaker then presented several charts to show how the depth pressure recorder furnishes a graphic record of the entire testing operation, and briefly interpreted the pressures most commonly encountered in a drill stem test.

Fall Meeting Schedule

October 5 — Colonial Room, Lassen Hotel. W. E. Hassebroek, chief of the Mechanical Research and Development Section, Halliburton Oil Well Cementing Co., presented a paper on the hydrafrac process.

November 9 — Colonial Room, Lassen Hotel. W. O. Keller, Stanolind Oil and Gas Co., will present a paper entitled *Critical Analysis of the Effect of Well Density on Recovery Efficiency*, and L. E. Young, president of AIME, will visit the Section for this meeting.

December 7 — Colonial Room, Lassen Hotel. Election of officers. ★ ★ ★

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Mid Continent Section Activities

By Glenn M. Stearns

The Annual Round Up on September 23 followed the pattern it has maintained for the past several years as a successful and enjoyable party. James N. McGirl, district manager of exploration for Tide Water Associated Oil Co., was host to the Section for the Round Up at his suburban home near Skiatook. The group began to assemble in late afternoon, and by the time the bones started to gallop, 172 members and guests had registered. The party differed from previous years in that AIME members did all of the work except for barbecuing the meat. Committee assignments were capably handled, and this plan resulted in a considerable saving to members on the cost of the meal. Pictures of some of those attending are shown on the page to the left in the following order, left to right:

1 — The line forms for food.

2 — Bernie Wilder, L. E. Wilsey, A. M. Derrick and R. W. Feagan, all of Stanolind.

3 — P. A. Dickey, Carter; J. P. Everett, Oklahoma A.&M.; and R. A. Morse, Stanolind.

4 — R. E. McMillen, Ohio; Wm. Schoeneck, British-American; Kenneth Teis, consultant; Lloyd E. Elkins, Stanolind; and Bob Ford, Schlumberger.

5 — J. R. Hatfield, Cities Service, Bartlesville, throws a horseshoe.

6 — Section members who served the food: H. D. Collins, Aberdeen Pet.; John Evinger, Deep Rock; Ralph Perry, W. B. Davis, Robert Barton, and E. W. Brake all of Gulf.

7 — C. W. McIntosh Earlougher Engineering; James Conner, Stanolind; Bill Perrine, Manahan Oil; Luther Myers, Bethlehem Supply; John Nation, Coop. Ref. Assn.; and H. M. Cooley, Bethlehem Supply.

8 — J. N. McGirl, host to the Round Up.

9 — M. R. Smith, Gulf; H. Riley, Stanolind; W. E. Allen, Gulf; and W. L. McCann, Stanolind.

10 — R. G. Hamilton, independent; V. T. McGhee, Phillips; G. R. Elliott, Phillips; and Rus H. Gwinner, Sunray.

11 — Somebody tells a story of questionable delicacy.

12 — John Buthod, student, Tulsa Univ.; George Bauer, Roach Equipt.; H. N. Britton, G. E. Sherrod, and Bert Brown, all students, Tulsa Univ.

13 — Roy Smith, Stanolind, and Jack Tarner, Phillips.

14 — Karl Lellky and F. A. Christanelli, both of Baroid in Houston, furnished entertainment for the party with an accordion and concertina.

15 — Charles Earlougher, Earlougher Engineering; John Redmond, Shell; and John Jennings, Ohio.

16 — D. C. Arnold, Natl. Bank of Tulsa, and W. L. Kendall, First Natl. Bank, Tulsa.

17 — Jack Stewart, Atlantic, and Raymond Richards, Tide Water.

Lewis E. Young, president of AIME, encountered a busy schedule when he visited Tulsa on September 12, 1949. At a breakfast meeting with ten AIME officers and executive committee members, Young discussed plans and problems relating to section activities, publications and meetings. He demonstrated a particular interest in study group activities which have been sponsored by the Mid-Continent section for the past two years. Activities of the study groups, one dealing with drilling and production problems and the other dealing with reservoir engineering, are to be summarized and submitted for later publication in the JOURNAL and other publications of the Institute.

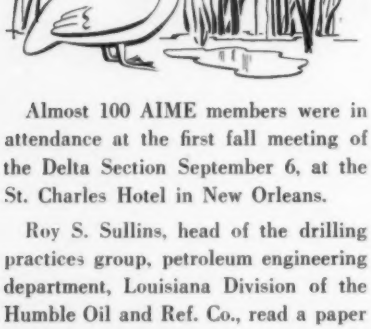
At ten o'clock in the morning Young appeared before an assembly of approximately 100 advanced petroleum engineering students at the Univ. of Tulsa. He made an inspiration talk in which he emphasized the need for technically trained men in every part of the world and stressed the advisability of continually pursuing a broad education after college graduation.

Lewis E. Young, president of AIME, addressing a joint luncheon meeting of the Engineers Club of Tulsa and the Mid-Continent Section of AIME on September 12.

At noon Young addressed a joint luncheon meeting of the Engineers Club of Tulsa and the Mid-Continent AIME section. This meeting was attended by approximately 175 engineers. Young related the procedure of King Solomon in asking for engineering assistance from King Hiram of Tyre in building his temple. He recounted other instances in which it has been necessary for countries to exchange technical knowledge and experience, and paid tribute to the remarkable development of foreign lands by American venture capital. "Our geophysicists and petroleum engineers have gone into every continent and their crusade in the search for petroleum has played a most important part in the industrial and social development of many lands. The exploration, development, and produc-

Continued on page 17

Glenn M. Stearns, Development Supt. for Stanolind, is JOURNAL Secretary for the Section. A native of Wheeler, Texas, he received a B.S. in P. E. from Okla. Univ., in 1936, and joined Empire Oil and Ref. Co. In 1938 he became Asst. Prof. of P. E. at Okla. Univ., where he wrote several technical papers and over 150 articles for the Oil and Gas Journal on "Engineering Fundamentals". In 1944 he joined the West Edmond Field Eng. Assn., and upon its dissolution in 1947 he affiliated with Stanolind's producing dept.



Delta Section Activities

By J. Paul Ratliff, Jr.

Almost 100 AIME members were in attendance at the first fall meeting of the Delta Section September 6, at the St. Charles Hotel in New Orleans.

Roy S. Sullins, head of the drilling practices group, petroleum engineering department, Louisiana Division of the Humble Oil and Ref. Co., read a paper entitled *Deep Well Drilling in the Gulf Coast Area.*

The speaker gave a brief review of the minor problems of deep well drilling, such as viscosity and filtration of the drilling fluid, stating that the most common viscosity-reducing agents used below 10,000 ft. are alkaline-tarmate or alkaline-lignin compounds. The desired filtration rate may be maintained in most cases by the addition of caustic and quebracho, starches, vegetable gums, or cellulose compounds.

To prevent lost returns several recommendations were made such as the use of longer strings of protective casing, use of cement or other material in zones of local weakness, reduction of annular velocity, use of low filtration mud and frequent reaming of the open hole.

Sullins stated that the present trend is toward the use of larger drill pipe and pumps in order to obtain high circulating rates.

Mark Krause, assistant Louisiana Division petroleum engineer for Humble Oil Co., presided at the meeting, substituting for E. N. Dunlap, Section Chairman.

Future Activities

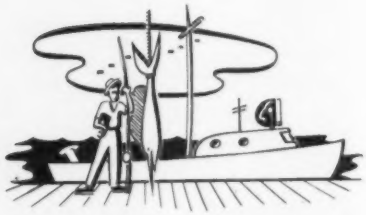
October 11, 1949 — E. G. Robinson, vice president, Shell Oil Co., Calgary, Canada, and N. M. Manville, petroleum engineer, Sinclair Prairie Oil Co., Baton Rouge, discussed company organization at the Petroleum Club of New Orleans.

October 28, 1949—Hallowe'en dance and buffet dinner, Metairie Country Club, New Orleans.

November 8, 1949 — A panel discussion entitled "Problems of Offshore Drilling", by experts representing all companies now active in offshore drilling.

December 13, 1949 — W. H. Stewart, Sun Oil Company, Beaumont, Texas, will speak on "Gas Condensate Well Corrosion Problems".

January 10, 1950 — A paper on water injection at Mamou field is being arranged for by D. V. Carter, chief petroleum engineer, Magnolia Petroleum Co., Dallas.



Southwest Texas Section Activities

By Raymond Keller, Jr.

A total of 233 members and guests attended the September 14 meeting in Corpus Christi to hear J. L. P. Campbell discuss radioactivity well logging. Campbell is with Lane-Wells Co. in Houston, and he used a series of large charts to demonstrate gamma ray and neutron radioactivity well log correlation and application. Pointing out that this type of logging has 19 different uses, he emphasized its application to the Gulf Coast area, and stated that its use has expanded greatly there within recent years.

Campbell's paper was fully reviewed in the July JOURNAL under North Texas Section Activities.

Section business transacted at the meeting consisted primarily of reports on the ensuing Branch Meeting in San Antonio. In addition, discussion brought out the need for more directors in the Southwest Texas Section. A motion was made by E. C. Sargent that the bylaws of the Section be amended to the effect that eight directors be elected annually, of which four would be located in Corpus Christi, and four would be located elsewhere, with the past chairman of the Section to be included as an ex-officio member of the Board. This motion was seconded by H. D. Vaughan and carried in a vote.

Ranseur and Leeton Receive Promotions

Weldon W. Ranseur has been named zone production superintendent for the Gulf Ref. Co., with headquarters in Laurel, Miss., replacing T. R. Bibee who was transferred to Houston, Texas. Ranseur joined Gulf in 1937 after graduating from A.&M. College of Texas with a B.S. in petroleum engineering. He worked throughout South Texas before coming to Laurel in July, 1944, as zone petroleum engineer. He has been active in work with the API and the Mississippi Sub Section, AIME. He helped organize the Sub Section and served on the board of directors in 1947; he served as chairman in 1948, and is now again on the board of directors.

Harold B. Leeton, who is first vice-chairman of the Mississippi Sub Section, and was formerly Assistant Zone petroleum engineer, replaced Ranseur as Zone Petroleum Engineer.

Oklahoma City Section Activities

By Harold Sells

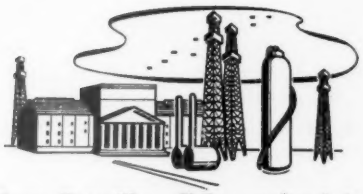
The Section opened the 1949-50 season Monday, September 12, with a buffet dinner which featured an address by AIME president, L. E. Young. Following the dinner Lincoln F. Elkins, Section chairman, introduced the Section officers, and also the officers present who were visiting from other sections.

Lloyd E. Elkins, Petroleum Branch chairman, introduced President Young, who held the close attention of the group with an interesting address. His address is summarized under Mid-Continent Section Activities in this issue of the JOURNAL.

An interesting visitor to many was Harold E. Robbins, an AIME member from Potrerillos, Chile, employed in that country by the Andes Copper Mining Co. Robbins was the guest of Dewey J. Sabin, Sohio Pet. Co., who formerly worked with him in Chile. Sabin first became a member of AIME in 1921.

Members of the Section wish to express their appreciation to the organizations that assisted in making this meeting a successful one.

Several members appear to be happy over the refreshments available for the meeting.



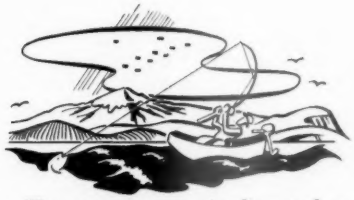
Pacific Junior Group Activities

By I. A. Marshall

Ninety-eight members and guests of the Junior Section of the Pacific Petroleum Chapter attended a meeting on September 8 at the Rio Hondo Country Country Club in Downey, California.

Chairman C. T. McClure presided, and Norman Clark, program chairman, introduced the speaker, E. C. Babson, Union Oil Co. of California.

Babson opened his talk on "Reservoir Performance" by discussing the three limiting types of single drive reservoirs and the factors which affect their performance. The depletion type of reservoir depends upon the expansibility of the oil and gas present for the driving force to bring the oil into the well bore. Other factors, besides driving force, which affect performance are: resistance to flow, size and shape of reservoir, and the method of operation. Examples of depletion type reservoirs cited were the Coastal Sespe production, the Stephens Zone in the San Joaquin Valley, and the Miocene sands of the Los Angeles Basin.



The second reservoir discussed was the gravity drainage type of which few are found in practice. Possible examples are the Lakeview field of the Midway-Sunset area, and portions of the Santa Maria field. High permeabilities and a closed reservoir are the main characteristics.

The water drive reservoir, of which there are none in California, was the third limiting type discussed. No pressure decline and constant gas-oil ratios are characteristics of this type.

Babson next discussed the various arrangements of the limiting type reservoirs which make up the combination and compound reservoirs. Combination reservoirs were broken down into closed and open types. Conservation operational policies were recommended in producing compound reservoirs in order to avoid the many hazards such as bleeding off gas caps and drowning out through high permeability sands.

Society of Rheology to Hold Annual Meeting in New York

The 20th Annual Meeting of the Society of Rheology will take place at the Hotel New Yorker in New York City November 4-5. Of possible interest to the petroleum industry are the following papers to be presented:

"Some Aspects of the Viscosity of Solutions", R. Simha, National Bureau of Standards.

"The Flow Birefringence of Polystyrene Fractions in Solution", F. R. Eirich, Poly. Inst. of Brooklyn.

"Creep of Polystyrene as Influenced by Temperature, and Correlation with the Activation Energy Theory", W. J. Worley and W. N. Findley, Univ. of Illinois.

"Dilute Solution Viscosity Behavior of Polymethylmethacrylate", J. Price, T. Alfrey, Jr., and A. Goldberg, Poly. Inst. of Brooklyn.

A number of other papers will also be presented, and non-members are welcome at the meeting.

BISHOP CRADDOCK GETS PROMOTION

Bishop Craddock of Sundown has been advanced from field superintendent of the Slaughter field to Mid-Continent Division field superintendent by Honolulu Oil Corporation. Craddock has been with Honolulu about 12 years. He was formerly employed by The Ohio Oil Co., Humble Oil and Ref. Co., and various independent contractors. His headquarters will continue to be in the Honolulu Oil Corp.'s field office at Sundown.

Personals

S. F. SHAW, gas-lift specialist, of San Antonio, is visiting in Calgary where he will be engaged in gas-lift investigations during September and October.

CLAUDE P. PARSONS has settled at 1265 North Kenmore, Los Angeles, and offers prime ribs at Lowry's to old friends who call him.

J. ROY DERRICK has joined the firm of King, Warren and Dye, Midland independent oil operators. Derrick will be assistant to Phil Yeckel, general manager, and a partner in the firm. He will also supervise production for the partnership.

...need we say more?

FRANKLIN D. COOPER
321 Lansdowne Road
DE WITT, NEW YORK

Consulting Engineer

August 9, 1949

Telephone
Syracuse 72-5190

American Paulin System
1847 South Flower Street
Los Angeles, California

Gentlemen:

On July 9, 1949, I made an altimeter survey of the Susquehanna River and Owego Creek at Owego, N. Y. This preliminary survey was made in connection with the Owego, N. Y., Flood Control Project.

The Village of Owego had run a line of levels several miles along the low water line of the Susquehanna River. In spite of unfavorable weather, your latest model Micro surveying altimeter checked the levels run by the Village of Owego within a foot.

I am convinced that your latest Micro altimeter is equivalent in precision to the finest theodolite.

In connection with the above altimeter survey, I was only able to get readings from the local weather bureau office to the nearest 5 ft. I would therefore like to purchase a second Micro altimeter to be read every 10 minutes.

You may be sure that I am telling all of my associates of the performance of your fine instrument.

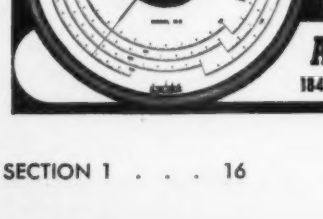
The workmanship on your instrument is as fine as I have seen on any instrument anywhere.

I was amazed at the performance of your instrument; and you may be sure that wherever I use it, I will recommend it wholeheartedly.

Very truly yours,

F. D. Cooper

Franklin D. Cooper, P. E.



MICRO SURVEYING ALTIMETERS

AMERICAN PAULIN SYSTEM

1847 SOUTH FLOWER STREET LOS ANGELES 15, CALIFORNIA

J. French Robinson, president of East Ohio Gas Co., was principal speaker for the petroleum luncheon at the Branch Meeting in Columbus, Ohio, Sept. 26 and 27. He presented an interesting 15 minute commentary on the film, "Natural Gas — A New Giant", which was prepared for the company by Robert Yarnell Ritchie. It is an outstanding documentation of the value of natural gas in our economy, and has won several awards in the industrial and public relations field.

Student Activities

The Texas A.&M. Petroleum Engineering Club held its first meeting for the school year on Wednesday, September 21, 1949, in the petroleum engineering lecture room. The meeting was called to order by Charles F. Underiner, president, and the meeting was held open for the election of secretary and treasurer. Officers elected were George S. Kent, secretary, and Bill G. Holcomb, treasurer — both are junior petroleum engineering students. After the election, Robert L. Whiting, club sponsor, gave a short talk on the advantages of students becoming affiliated with the AIME. The membership committee and entertainment committee were appointed after which the meeting adjourned, and two movies were shown. The first was a Halliburton film entitled, "We'll Get There Somehow," and the second was "Football Highlights of 1948," an Humble production. Over 160 people attended this meeting and it is expected that a large number will attend following meetings, which occur semi-monthly, because of the interesting programs which have been outlined.

Employment Notices

Continued from page 8

♦ Drilling foreman, 30 years' experience in cable tools and rotary drilling in Africa, Europe, India, South America, and the United States. Capable of directing road, derrick, and bridge construction and other exploration work. Experience with high-pressure drilling, toolpushing, and fishing jobs. Recently completed a course in gravel packing of water wells in Canada. Speak German, Hungarian, Spanish and Italian. Desire position as drilling foreman or driller. Code 111.

POSITIONS

♦ Associate professor, doctor's degree, with some practical experience in petroleum geology, to handle courses in petroleum geology and paleontology, including micropaleontology; and also to handle the instrument work of field geology. Salary dependent upon qualifications. Location, Missouri. Y-1497(b).

♦ Assistant or associate professor with industrial experience in petroleum production engineering, to teach petroleum production courses. Salary open, depending upon qualifications. Location, South. Y-2415.

♦ Senior research engineer, graduate, with either a doctor's or master's degree, with a minimum of five years' experience in production technological research. Will direct petroleum engineering research and technical service laboratory. Will direct research and technical service work in the following problems: Improved drilling fluids and improvement of old drilling fluids; completion practices; core analysis; physical properties of reservoir fluids; development of instruments to measure variables to determine performance of reservoirs. Y-2685(a).

♦ Production engineer, graduate, with about five years' experience in oil and gas reservoir engineering. Knowledge of production technology research. Will make comprehensive studies of oil and gas reservoirs and determine the most efficient control and production methods for maximum recovery. Cooperate in the recommendation of the design and operation of all production equipment. Coordinate production practice with laboratory research problems. Recommend on locations of wells and methods of well completions. Location, Saudi Arabia. Y-2685(b).

Mid Continent Section Activities

Continued from page 13

tion record of American geologists and American corporations in the petroleum world is probably the most conspicuous example in history of what can be accomplished by technologists and venture capital in a system of private enterprise."

He expressed the opinion that scientific and technical knowledge alone has not been responsible for the dominant position of the United States in the industrial world. Among the other factors that have played an important part in winning and holding this position are: (1) Talent and genius for dynamic leadership in production, (2) cooperation of labor and management in free private enterprise, (3) adequate venture capital, and (4) experienced and efficient administration by men of vision.

He adapted a quotation from an English clergyman, "No man is an island, he is a part of a continent," to illustrate that every man is a part of the community and should take part in community activity. He quoted a poem by Kipling relating the manner in which the "sons of Martha" (engineers) are serving "the sons of Mary" (public).

In the afternoon Young was accompanied to Oklahoma City by Lloyd E. Elkins, Branch chairman, and Herbert M. Cooley, chairman of the Mid-Continent section. After his speaking appearance before the Oklahoma City section he travelled by plane to El Paso, Texas, in company with Lincoln Elkins, chairman of the Oklahoma City Section, Lloyd Elkins and Cooley.

Gulf Coast Section Activities

Continued from page 9

in 1933 and were instigated by the former Secretary of Interior Harold Ickes. Investigations went further as a result of additional agitation, and a bill was finally introduced in Congress whereby the Government would quitclaim any title to these coastal submerged lands. The bill passed, but President Truman vetoed it on the grounds that it was a legal matter and should be passed on by the Supreme Court before any Congressional action was made. The Attorney General filed suit on behalf of the Government to gain title of the offshore lands adjoining California. As a title suit, it had to be on a presumption of ownership in fee by the government, a presumption on which there was no prior justification legally or politically. The Supreme Court ruled that the Attorney General had the authority to file such a suit and passed on the suit in favor of the Federal Government. The basis on which the Government claimed ownership has not yet been clearly established.

Nothing in the history books states that the boundaries of the United States extends three miles, three feet or three inches beyond the shores. The U. S. Supreme Court ruled that the Government owned it simply because it seems natural to the Supreme Court that the Government should own it. It said that since the individual states cannot go to war, the Government must have paramount rights in and over the tidelands to fulfill its obligations of defense. The point so far is that the Supreme Court passed on a matter out of its jurisdiction. The boundaries between the United States and Canada, and between the U. S. and Mexico are established by Congress and not by the courts. It is a question for Congress to decide in making any boundary limitation. The Supreme Court says that the Government owns the three-mile belt adjoining California, but there is no bill which states this fact. Today, there is a majority in the House in favor of a Government quitclaim bill, but there is not a majority in the Senate, and the President is opposed to it. House Resolution 5991 and 5992 have been introduced to provide for Federal ownership of the tidelands. According to the Supreme Court ruling, the Government owns the three-mile belt, while in some cases, the individual states exert ownership over that area beyond. As the situation now stands, it will be a long, long time before we really know who actually owns the tidelands and who can give leases.

A sound color movie entitled "Petroleum Operations in the Gulf of Mexico" followed the main discussion. This movie was a joint venture between several oil companies active in the Gulf. The problems that are involved, the difficulty of operations due to the open sea, and the tremendous risk involved were vividly presented. The movie ended with the prediction that an additional five years would be required before offshore production would reach 250,000 barrels per day.

Professional Services

This space available only to AIME members. Rates upon request.

AMSTUTZ AND YATES, INC.
Consulting Petroleum Engineers
Valuations
Reservoir Analyses
Geologic Investigations
406 KFH BLDG., WICHITA 2, KANSAS

CARLTON BEAL
Consulting Petroleum Engineer
11699 BELLAGIO ROAD
LOS ANGELES 24, CALIFORNIA
Phone: ARizona 74294

FRANK N. BOSCO
PETROLEUM ENGINEERING
Exploration — Evaluation — Operation
838 Symes Building — *By Appointment Only*
PHONE: TABOR 7361 — DENVER, COLO.

JOHN G. CAMPBELL, CHEMIST
Field Charcoal & Podbielniak Analyses
Waters — Oil Field Brines — Cores
422 N. Lower Broadway, Corpus Christi, Texas

PAUL CHARRIN
Consulting Engineer
ATLAS WELL SERVICE CORPORATION
UNIVERSAL EXPLORATION COMPANY
913 Union National Bank Building
HOUSTON 2, TEXAS
Phone: Preston 0060

ALEXANDER M. CROWELL
Natural Gas Consultant
So. Arkansas — LOUISIANA — Coastal Texas
NEW ORLEANS — SHREVEPORT
1415 Carondelet Bldg. — 3746 Richmond Ave.
Phone: Raymond 3861 — Phone: 8-1419

CRUTCHFIELD AND PRUETT
CONSULTING PETROLEUM ENGINEERS
224 Wilson Building
CORPUS CHRISTI, TEXAS
John W. Crutchfield — *Horton T. Pruett*

ALEXANDER DEUSSEN
Consulting Geologist and Petroleum Engineer
Room 413, Commerce Bldg. Addition
HOUSTON 2, TEXAS

EARLOUGHER ENGINEERING
Petroleum Consultants - Core Analyses
Specializing in Secondary Recovery investigations - Appraisals - Operations
311-319 East Fourth Street
TULSA 3, OKLAHOMA
Office 2-5129 — Laboratory 2-6139

FARIS & WARREN
Consulting Petroleum Engineers
McClintic Building
MIDLAND, TEXAS
Production & Reservoir Engineering
Evaluations — Development

HERSHAL C. FERGUSON
Consulting Geologist and Paleontologist
Esperson Building
HOUSTON, TEXAS
825½ Gravier Street — New Orleans, La.

FITTING, FITTING & JONES
Engineering & Geological Consultants
Petroleum — Natural Gas
Box 1299
PERMIAN BLDG. — MIDLAND, TEXAS

WILLIAM HURST
Petroleum Consultant
Reservoir Engineering - Primary & Secondary Recovery, Gas Cycling, Evaluations
6445 BROMPTON ROAD
Madison 1181
HOUSTON, TEXAS

MICHEL T. HALBOUTY
CONSULTING GEOLOGIST
AND PETROLEUM ENGINEER
Shell Building
Houston 2, Texas — Phone P-6376

H. L. KIRKPATRICK
CONSULTING PETROLEUM ENGINEER
Property Management - Well Completions
Proration - Reports - Appraisals
445 Delaware Avenue
SHREVEPORT, LA. — PHONE 7-8295

CLEVELAND O. MOSS
CONSULTING PETROLEUM ENGINEER
Estimates of Oil and Gas Reserves
Valuation--Production Problems--Proration
208 MIDCO BLDG. — TULSA 3, OKLA.

ERNEST K. PARKS
CONSULTING PETROLEUM ENGINEER
Planning, Direction and Examination of Oilfield Operations, Estimates of Oil and Gas Reserves, Oil Property Valuation
614 S. HOPE STREET, LOS ANGELES, CALIF.
Telephone: VanDyke 4659

NORRIS JOHNSTON
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PETROLEUM TECHNOLOGISTS, INC.
Production Research — Core Analysis
Reservoir Engineering
868 TRUCKWAY, MONTEBELLO, CALIFORNIA
PHONE: UNION 1-5338

HARRY H. POWER
Consulting Petroleum and Chemical Engineer
Production, Reservoir, Valuation and Development Engineering
P. O. Box 1542 — University Station
AUSTIN, TEXAS

A. L. SELIG
Consulting Petroleum Geologist
GULF BUILDING — HOUSTON, TEXAS

S. FRED SHAW
Gas Lift Specialist
301 Terrell Road, Phone: T-9754
SAN ANTONIO, TEXAS

WM. H. SPICE, JR.
Consulting Geologist
2101-03 Alamo National Building
SAN ANTONIO 5, TEXAS

HARRY C. SPOOR, JR.
Consulting Geologist
Petroleum . . . — . . . Natural Gas
COMMERCE BLDG. — HOUSTON, TEXAS

JOSEPH B. UMPLEBY
Geologist and Engineer
Office Consultation Only
5945 LUTHER LANE
DALLAS 5, TEXAS

HAROLD VANCE
CONSULTING PETROLEUM ENGINEER
Pet. Engr. Dept. — A & M College
College Station, Texas

BASIL B. ZAVOICO
Petroleum Geologist and Engineer
220 E. 42nd St. — City National Bank Bldg.
New York 17, N. Y. — Houston, Texas
MUrray Hill 7-7591 — Charter 4-6923

aime NEWS

Southern California Section Fall Meeting

All divisions of the Southern California Section, including metals, mining and milling, industrial minerals, and petroleum, will participate in the fall meeting on Oct. 20 and 21. Los Angeles, of course, is the host town; metals division meetings are to be held at the new Institute of Aeronautical Science building, while the petroleum, industrial minerals, and mining and milling division meetings will be at the Elk's Club.

Two full days of technical sessions are scheduled for the petroleum group by general chairman John T. Thatcher, Jr. Thursday, the Town House will be host for the oil men's luncheon.

This year the industrial minerals, and mining and milling divisions will join together for a two-day session. Ian Campbell and George Dub have planned for numerous papers by good men on interesting subjects.

Four papers are listed for the metals division on Thursday afternoon and evening, with the meeting taking the form of a symposium on creep of metals. Fred Boericke is chairman.

The annual all-division luncheon of the Section will be on Oct. 21 at the Town House. In addition to other business, Student Awards will be presented.

The men responsible for the programs have spent a lot of time getting them ready for you so that you will be assured of an interesting and profitable time.

Walter Hull Aldridge, John Fritz Medalist for 1949

Announcement has just been made by the John Fritz Medal Board of Award of the award of the John Fritz Medal for 1949 to Walter Hull Aldridge, president of the Texas Gulf Sulphur Co., and recipient of the AIME Saunders Mining Medal in 1933. This board of award is composed of four representatives, all past presidents, from each of the four Founder Engineering Societies. The medal is called the "medal for medalists," regarded as the highest honor an engineer may attain.

Further details regarding the career and professional achievements of the Medalist will be published in a forthcoming issue of the journals.

The citation reads:

"WALTER HULL ALDRIDGE

As Engineer of Mines and Statesman of Industry who by his rare technical and administrative skills has importantly augmented the mineral production of our country and Canada, and who by giving unselfishly of his wisdom and vision has guided his professional colleagues to higher achievements."

AIME and ASME Joint Meeting

The final draft of the program for the twelfth joint meeting of the Coal Division, AIME, and the Fuels Division, ASME, to be held at French Lick Springs Hotel, Oct. 26 and 27, has been completed. It looks like a program which fuels men can't afford to miss. For a list of papers see page 51 of *Mining Engineering*. The banquet speaker is to be Philip Willkie, son of the late Wendell Willkie. A program is being prepared for the ladies which will include a visit to the French Lick Springs Hotel gardens, bridge, dancing, and a bus trip to the nearby Indiana State Park limestone cave.

Get on the ball, you fuels men, and your ladies; get your facts and fun at French Lick.

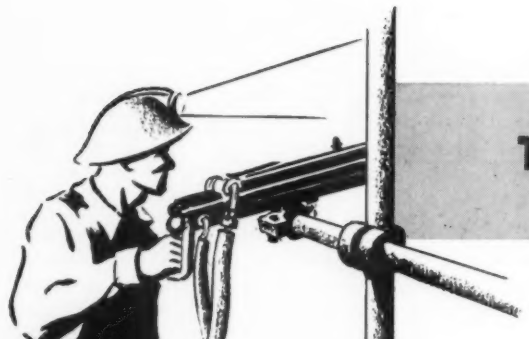
Pittsburgh Section Off-the-Record Meeting

The Pittsburgh Section has gone all-out to plan its Oct. 28 meeting to interest coal, petroleum, open-hearth, and metals men. Programs for each group are listed in the related journal but get to the meeting if you can possibly make it. You'll find it worthwhile.

The Coal Division sessions will be held in the Pittsburgh Room of the William Penn Hotel; all other sessions will be on the 17th floor. There will be a luncheon and dinner and at the latter, two special motion pictures will be shown, the first on air-borne missiles, and the second on the defense of Antwerp during the Battle of the Bulge.

Industrial Minerals Division Meets in Tampa

Tuesday, Nov. 8, is registration day for the annual fall regional meeting of the Industrial Minerals Division; the Tampa Terrace Hotel, needless to say in Tampa, Fla., will be headquarters from Nov. 8 to 12. Two days of technical sessions are scheduled for Wednesday and Thursday featuring papers on geology, mining, and milling of Florida phosphates and other mineral resources, and papers on industrial minerals in the southeastern states. A cocktail party and banquet wind up Thursday's affairs, but be up for the field trips on Friday and Saturday to a limestone quarry, a heavy mineral operation, and the phosphate producing areas. If you want to stay over Saturday evening, there's the University of Florida-University of Kentucky football game.



THE DRIFT OF THINGS

. . . as followed by EDWARD H. ROBIE

1950 Dues Bills

To expedite the recording and acknowledgment of remittances, the plan of staggering the mailing of dues notices is being continued this year. First to be sent out have been the bills to our members outside of the U. S. A., for these will require more time in transit, and often delay is incurred in securing American dollars. Mailing of all bills will be completed in late December. It is hoped that members will respond as promptly as they can, although dues do not actually become payable until January first.

Those who have found the dues bill more or less complicated in previous years will, we hope, find the current statement simpler and more acceptable. It is predicated on the assumption that a member will wish the same Branch journal or journals in 1950 that he has been receiving in the past. If he wishes to change his selection he should so state on the bill and correct it accordingly. Members are entitled to receive free, as part consideration for their dues, a 1950 subscription to one of the following: **Mining Engineering, Journal of Metals,** or **Journal of Petroleum Technology.** If two different journals are desired the additional charge is $4, or if all three are wanted the added charge is $8. Additional subscriptions to the same journal must be paid for at the nonmember price —$8 each for the Americas and $9 foreign.

The technical papers published by each of the three Branches of the Institute appear monthly in the respective journals. Enough extra copies of these technical papers are printed each month so that they can be bound together at the end of the year into Transactions volumes, supplied at cost to those who wish to have them. Such bound copies for members' libraries preserve a complete file, in permanent form, of the technical publications of the respective Branches of the Institute. Although one may try to keep individual copies of the journals, often one or more will become lost.

These three Transactions volumes will be published in January of each year, each containing all the technical papers, discussion, and an index, published by the respective Branches in the previous year, and nothing else. Members that have already requested one or more of these volumes to be published next January will find the appropriate charge therefor on their bills. Those that did not so specify on their publication selection slips last year, but now wish to have one, should add the item to their bill and enclose an additional $3.50 for each volume selected; so long as our limited supply lasts they will be accommodated.

We shall assume that members will wish to receive, early in 1951, the same bound volume or volumes, if any, that were selected in 1950 and shall govern our overrun printing accordingly, unless we are advised to the contrary. The price of the 1951 volumes cannot be set until their cost is known but it should not be greatly different from the current price of $3.50.

No Institute Directory was published in 1949 but the usual volume will be prepared in the spring of 1950. Members that have not already advised Institute headquarters of any desired change in their listing should do so in the next few months, for no special canvass will be made for Directory purposes.

Bills will be sent out in duplicate, one copy to be returned to the AIME with remittance and the other to be retained for the member's record. If payment is made through a bank or agent, they should be sent both copies with the request that one be returned to the Institute, or at least they should advise us of the member's name and ledger number when making payment, so that proper credit may be accorded. The ledger number is the number that appears opposite the name on the address stencil.

Student Associates again in 1950 will have the privilege of selecting one of the Branch journals if they pay $4.50 dues. If they do not wish to have an annual subscription to a journal their dues are $2. They will be billed according to the amount they paid in 1949 but of course have the privilege of changing their classification for 1950 if they wish.

Mudd Volumes for Junior Members

For years, all Junior Members of the AIME, at the time they attain that status, have been given several volumes thought to be of interest to them, through the Seeley W. Mudd Memorial Fund. A dozen or more titles have been distributed in all. Currently each Junior Member is receiving a copy of the Institute's 75th Anniversary volume plus a copy of the new ECPD book, "A Professional Guide for Junior Engineers." Also, he is given the privilege of selecting, as a third volume, one of several books that

are in more limited supply and not of as wide professional interest.

The Mudd Fund Committee hopes, in the next year or so, to be able to supply books of special interest to young men in each of the ten Divisions of the Institute, as well as two or three volumes of general interest to all groups. Currently, for instance, no book is being offered of special interest to young petroleum engineers. Each Division is being asked to select the subject and potential author for such a book, and suggestions from the Junior Members themselves will be welcomed. The books should be concise and practical, preferably covering a subject of wide technical interest to Division members, and also preferably filling a gap in current technical literature. They may possibly take the form of a handbook. If they are of such a nature that they can be sold, to others than Junior Members who will get them free, so much the better for the Mudd Fund.

Steel and Coal

When this issue reaches its readers, they will know much more than we do now—on Sunday, Sept. 18th—whether or not a steel or coal strike is going on or is imminent. The report of President Truman's fact-finding board was a masterful compromise that satisfied neither side. Fortunately no general wage increase, for the steel or other industries, was recommended, and the amounts demanded for social insurance and pensions were reduced considerably below Mr. Murray's initial demands. The disagreement, bitter on both sides, is not on whether pensions are desirable — but whether workers should contribute to part of the cost.

The threatened coal strike has quite a different reason. The twenty-cent a ton royalty for miners' welfare seems never to have been adequate for the benefits paid, and certainly not after the three-day week reduced output from eleven to eight million tons. A group of Southern operators has refused to pay any royalty at all on coal mined since July 1, when the contract expired, the royalty agreement being a part of the contract. Mr. Lewis says this has made the miners boiling mad and they may quit work any time, which will mean still less money in the welfare fund.

To us, it seems unfortunate that social insurance and pensions ever should have become a matter for company-union negotiation. Had employers been more farsighted they would have urged more adequate payments under the Federal laws and thus perhaps have avoided individual company responsibilities in this regard. One bad feature of such plans from the economic standpoint, unless they are liberalized, is that they tie the employe to one company and thus do not promote a mobile labor supply in the country, a desirable factor for efficient production.

Sharing Our "Know How"

Point Four of President Truman's recommendations made to Congress last June has attracted considerable attention. It has to do with assistance to the peoples of economically undeveloped areas to raise their standards of living. The suggested aid falls into two categories: (1) technical, scientific, and managerial knowledge necessary to economic development; and (2) production goods — machinery and equipment — and financial assistance in the creation of productive enterprises. The President especially mentioned the fields of mining and metallurgy in referring to the need in underdeveloped countries for technicians and experts.

Assistance so far has been more in imparting American know-how to visitors from foreign countries than in sending American technologists abroad. More than 25,000 foreign students were enrolled in American universities in the college year just closed, and approximately 5100 of these were studying engineering. The ECA has just announced that fifty British engineers, with at least Master's degrees, will be brought to the United States this fall for one year of graduate training in practical applied science and technology, partly in schools and partly in plants. The cost will be about $3000 per man.

The Department of State hopes to send more technical men and teachers abroad in the future than in the past, but a start has already been made. For instance, George V. Allen, the State Department's Assistant Secretary for Public Affairs, who is intimately concerned with the project, recently cited the fact that two American mining engineers from the Bureau of Mines were now in Mexico assisting the Government in working out ore extraction processes. Also, many American geologists have been sent to Brazil in the last seven years to assist that country in locating and mapping its strategic minerals. The largest deposits of manganese in the Western Hemisphere have thus been discovered.

We feel that American firms in the mineral industry should cooperate to the fullest extent in these plans to promote world recovery, as many of them are now doing. Interested individual engineers should get in touch with the Department of State, Washington.

Arkansas Bonanza

Large mining companies have many offers of properties, and some of these offers are accompanied by reports that arouse the risibilities of the exploration engineers. Jack Baragwanath sends us a sample, a report of a mineral occurrence on a certain Arkansas farm which we will call the Smith farm, just to hide its identity and protect Freeport Sulphur from too much competition in securing an option:

"The starting point for the location of minerals is at the southeast corner of the Smith farm. The lead is located 1000 ft west of the said starting point and the vein runs thence northerly 1122 ft and averages 148 ft in width and about 25 ft thick. The ore is about 20-25 ft below the surface of the farm. The silver pocket is located 800 ft west of the starting point, thence north 300 ft to center of pour-out, thence north 200 ft to northerly edge of pocket. The pocket is 200 ft across at its widest part and about 38 ft thick. The ore is about 28 ft below the surface. There is a silver-copper vein about 15 ft wide through the pour-out at about 2000 ft down that runs the entire length of the Smith farm. The probable depth of the vein is about 1000 ft. [Then comes similar data about a copper pocket.]

"The Smith farm is one of the best that I have found in Ark. . . . There is a fortune in either of the three minerals. . . . The silver and copper were deposited in a molten form from a volcano and the lead was formed through filtration."

ITINERARY OF AIME SECRETARY

The Secretary of the Institute plans to be at the following places in the month of October:

Oct. 1. St. Louis and Rolla, Mo.
2. Baxter Springs, Kans.
3. Dallas
4. Austin
5-7. San Antonio (Petroleum Division)
8. Austin
10. Carlsbad, N. Mex.
11. El Paso
12. Silver City, N. Mex.
13. Morenci, Ariz.
14. Miami and Superior, Ariz.
15. Tucson
16. Tucson and Ajo, Ariz.
17. Ajo
18. La Jolla, Calif.
19-20. Los Angeles (Divisional Meeting)
21. Jerome, Ariz.
22. Albuquerque
24. Wichita
26. French Lick, Ind. (Fuels Conference)
27. La Fayette, Ind.
28. Chicago (ECPD Annual Meeting)

Mr. and Mrs. Robie are driving and are planning to visit as many Local Sections and Affiliated Student Societies as possible en route.

Fuels and Domestic Security

Fuels of the future, and their relationship to the domestic security of the United States will be discussed at the 29th annual meeting of the American Petroleum Institute in Chicago, Nov. 7 to 10. The fuels session will be held in the grand ballroom of the Stevens Hotel on Thursday morning, Nov. 10.

The forum will be opened with papers by W. M. Holaday of the Socony-Vacuum Oil Co., New York City, and W. G. Whitman of MIT. Holaday will discuss such questions as these: For maximum efficiency and conservation of our resources, should we use coal, liquid fuels, or gas? Which is best for power production, steam or internal combustion engines? What should be the fuel for steam power, coal, oil, or gas? What should be the fuel for internal combustion engines, Diesel fuel or gasoline?

Whitman will give his opinions on these questions: Who holds the responsibility for National Security? What about the fuel requirements for the next war?

Other Whitman questions revolve around these points: Timing of discovery and development—What is best for our country? Stockpiling versus imports—What should we do? Should we conserve our crude reserves and go the synthetic route, and if we do go the synthetic route what should we use in the production of synthetic fuels — gas, bunker oil, shale, or coal?

In Changing Your Address

When notifying AIME headquarters of a change of address, or of company position or affiliation, please mention the Branch of the Institute to which you belong—Mining, Metals, or Petroleum. This will make for a more expeditious handling of the change and will facilitate the preparation of various reports. A new Directory will be issued next spring; listings will be the same as in the 1948 Directory unless the Secretary's office has been notified of a change.

Gerow CIMM Secretary

Carlyle Gerow took office as secretary-treasurer of the Canadian Institute of Mining and Metallurgy

on Oct. 1. The AIME wishes him every success in his new post and anticipates a continuation of the fine fraternal spirit and co-operation that has characterized relations between our two institutes.

PRESIDENT YOUNG ON TOUR

President Young has already visited the Oklahoma City, El Paso Metals, Southwestern New Mexico, Carlsbad Potash and San Juan Sections of the AIME. Members in the following areas will have a chance to meet him as he continues his tour:

Oct. 1. Colorado School of Mines
4. Southeast Section, Birmingham
5. Univ. of Alabama, Tuscaloosa
6. Petroleum Branch, San Antonio
10. New Mexico School of Mines, Socorro
11. Colorado Section, Denver
12. Utah Section, Salt Lake City
14. Montana Section, Butte
14. Columbia Section, Wallace
15. Univ. of Idaho and Washington State Student Chapters, Moscow
17. North Pacific Section, Seattle
19. CIMM meeting, Vancouver
20-21. Southern California Section, Los Angeles
26. Coal Division, French Lick
27. Illinois Inst. of Tech., forenoon.
27. Univ. of Wisconsin, afternoon
28. Michigan College of Mines, Houghton
29. Upper Peninsula Section, Ishpeming

Nov. 7. Boston Section
8. Tri-State Section, Joplin (Tentative)
9. Kansas Section, Wichita
14. Arizona Section, Tucson
17. Lehigh Valley Section Luncheon (Tentative)

Dec. 7. New York Section
15. Coal Mining Institute, Pittsburgh

Jan. 9. Delta Section
10. Gulf Coast Section
11. North Texas Section
16. East Texas Section (Above Jan. dates tentative)
19. Ohio Valley Section

Personals

John Eliot Allen has joined the department of geology at the New Mexico School of Mines, Socorro. He had been at Penn State.

J. W. Allingham, 509 7th St., Calumet, Mich., is a geologist with the U. S. Geological Survey.

H. I. Altshuler has left Peru, where he was general manager of the Vanadium Corp. of America, to take the post of general manager for Frontino Gold Mines Ltd. in Colombia, now under the technical direction of the Gold Fields American Development Co., of London and New York. Mr. Altshuler's new address is care of Frontino Gold Mines Ltd., Segovia Antioquia, via Otu, Colombia.

Robert B. Anderson is on a year's leave of absence from the Inland Steel Co. to get a degree in electrical engineering at VPI.

Robert H. Arndt is a professor in the department of geology at the University of Arkansas, Fayetteville, Ark.

H. J. Ashe, recent graduate of the Colorado School of Mines, has a job with the Inspiration Copper Co. His address is Box 96, Inspiration, Ariz.

L. J. Barraclough, chief mining engineer to the 3,000-ton-per-day Indian coal company, Messrs. Andrew, Yule & Co., visited the States on business and as the delegate of the Mining, Geological and Metallurgical Institute of India to the UN Conference on the Conservation and Utilization of Natural Resources in August. An authority on hydraulic stowage in Indian mines, he holds several government appointments.

Mr. Barraclough left New York on his way home early in September after visiting coal mining properties in Pennsylvania. He suggests that any AIME members wishing to visit India should get in touch with P. K. Ghosh, Honorary Secretary of the Mining and Geological Institute of India, care Geological Survey of India, Calcutta, who will arrange for a proper reception.

H. L. Batten, who for some years has been consulting engineer for Canadian Exploration, Ltd., and manager of the Emerald Tungsten Project, Salmo, B. C., has established an office at 704 Birks Bldg., Vancouver, B. C., and will carry on a general consulting practice specializing in development projects in British Columbia.

Jacob P. Berry for the past two years had been general superintendent of Moccasin Mines, Ltd., at Watson Lake, Yukon Territory. Recently he resigned this post to become manager of the United Mining and Dredging Co. operating in the Cariboo area of British Columbia.

J. J. Kelleher

J. J. Kelleher has been made assistant sales manager, a newly created post, for the Hercules Powder Company's explosives department. For several years he was manager of the Company's contractors division. He has worked on some of the major construction jobs in the country.

Dwight L. Harris

Dwight L. Harris resigned as assistant professor of metallurgy in the School of Mines at Washington State to continue graduate work at MIT. A research assistantship at the Institute in radioactive tracer investigations has been granted him. He expects to complete work for a doctorate at the same time.

J. T. Boyd has an avocado grove near Carlsbad, Calif., and although somewhat slowed down by Parkinson's disease, has been making mine examinations in California, Nevada, and Mexico.

Walter W. Bradley married the former Mrs. John R. Roberts last April. While on a trip to the East Coast in August they stopped in at AIME headquarters.

Lloyd D. Brownson is assistant to the engineers of the U. S. Smelting Refining and Mining Co., at Lark, Utah.

E. L. Bruce, Miller Memorial professor and head of the department of geology at Queen's University, Kingston, Ont., has been elected vice-president of the Society of Economic Geologists for 1950.

R. D. Bradford, of San Francisco, has been named general manager of the Utah department of the American Smelting and Refining Co., succeeding **W. J. O'Connor,** who retired on May 1. Mr. O'Connor had served AS&R for 39 years, and spent 32 of them in Utah. Mr. Bradford joined the Company in 1926, and has worked in its New York, East Helena, Mont., and El Paso, Texas, operations.

J. Ross Clare, formerly with the Lamaque Mining Co., can now be reached in care of the Canadian Johns Manville Co., Matheson, Ont.

Frank A. Colbert is in Rancagua, Chile, working as junior mine shift boss for the Braden Copper Co.

W. A. Coster, formerly with the Demerara Bauxite Co., is carrying out an assignment for the Afghanistan Government.

Robert I. Davis is working for Cia. Minera Sta. Maria del Oro, Sta. Maria del Oro, Durango, Mexico.

Danford J. Dodds is employed by the Bagdad Copper Corp., Bagdad, Ariz., as assayer-chemist. Prospecting is good in that area and excitement growing over the recent discovery of U_3O_8 at the nearby Hillside mine.

Murl H. Gidel, chief geologist of the Anaconda Copper Mining Co., has been elected president of the Alumni Association of the Montana School of Mines for the ensuing year.

T. R. Goedicke has left Sherwin Kelly Geophysical Services to return to the University of North Carolina,

Chapel Hill, where he is studying for his doctor's degree in geology.

Patrick Green, formerly general mine foreman for Patiño Mines and Enterprises, may be reached temporarily at home, where his address is Box 622, Cashmere, Wash.

Thomas A. Greene is now an assistant engineer with the Anaconda Copper Mining Co., and can be reached at 2601 Princeton Ave., Butte, Mont.

Wm. A. Griffith, having completed requirements for a master's degree at MIT, where he was an instructor, has taken a job with the New Jersey Zinc Co. at Palmerton, Pa.

Donald R. Haake, formerly in the production department of the Rochester & Pittsburgh Coal Co., has gone to Wheeling, W. Va., as industrial engineer for the Valley Camp Coal Co.

George R. Haataja can now be reached in care of the Braden Copper Co., Rancagua, Chile.

Coming Meetings

OCTOBER

3 Boston Section, AIME.
3-4 National Assn. of Corrosion Engineers, Adolphus Hotel, Dallas, Texas.
3-6 Assn. of Iron and Steel Engineers, William Penn Hotel, Pittsburgh.
5 Chicago Section, AIME. R. S. Archer on "Temper Brittleness in Steels."
5-7 Petroleum Branch, AIME, fall meeting, Plaza Hotel, San Antonio, Texas.
6 American Iron and Steel Institute, Drake Hotel, Chicago.
7 Columbia Section, AIME.
10-14 American Society for Testing Materials, Fairmont Hotel, San Francisco.
11 Delta Section, AIME. Discussions on company organization.
11 East Texas Section, AIME.
11-14 American Standards Assn., annual meeting, New York City.
12 El Paso Metals Section, AIME.
12 Southwestern New Mexico Section, AIME.
12 San Francisco Section, AIME.
13 New York Section, AIME. M. L. Haider on "Canadian Oil Developments."
13 ASME, Metropolitan Section Night.
13-14 Texas Mid-Continent Oil and Gas Association, annual meeting, Rice Hotel, Houston.
14 Eastern Section, Open Hearth Committee, Iron and Steel Division, annual all-day fall meeting, Warwick Hotel, Philadelphia.
14 Southwestern Section, Open Hearth Committee, Iron and Steel Division, Kansas City, Mo.
14 Rio de Janeiro Section, AIME.
17 Detroit Section, AIME.
17-19 Institute of Metals Division, AIME, fall meeting, Allerton Hotel, Cleveland.
17-21 National Metal Congress and National Metal Exposition, Public Auditorium, Cleveland, Ohio.
17-21 American Society for Metals, annual meeting, Cleveland, Ohio.
17-21 American Welding Society, annual meeting, Cleveland, Ohio.
17-23 AIEE, 1949 Mid-West meeting, Netherland Plaza, Cincinnati.
18 Gulf Coast Section, AIME.
18 Washington, D. C., Section, AIME.
19 Southwest Texas Section, AIME.
19-20 Society for Non-Destructive Testing, Cleveland, Ohio.
20 Carlsbad Potash Section, AIME.
20 Utah Section, AIME.
20-21 S. Calif. Section fall meeting, with Petroleum, Mining and Metals Branches, Los Angeles.
21 Oregon Section, AIME.
24-28 Thirty-seventh National Safety Congress and Exposition, Chicago.
25 Montana Section, AIME.
26-27 Joint Fuels Conference, ASME-AIME, French Lick Springs Hotel, French Lick, Ind.
28 Pittsburgh Section of Open Hearth Committee and Pittsburgh Section, AIME, annual fall meeting, William Penn Hotel, Pittsburgh.
28 Delta Section, AIME, Hallowe'en dance and buffet dinner, Metairie County Club, New Orleans.
28-29 ECPD, annual meeting, Edgewater Beach Hotel, Chicago.
31 Alaska Section, AIME.

NOVEMBER

1 Society for Applied Spectroscopy, New York City.
1-5 Pacific Chemical Exposition, California Section, American Chemical Society, San Francisco Civic Auditorium.
2 Chicago Section, AIME. Ladies Night. J. P. Skinner on "Synthetic Sapphire."
2-4 American Society of Civil Engineers, fall meeting, Washington, D. C.
4 Columbia Section, AIME.
7 Boston Section, AIME.
7-10 AIChE, annual meeting, Pittsburgh, Pa.
7-12 International congress on tunnel driving in rock formation, organized by the Societe de l'Industrie Minerale. Information on meeting available from French Mining Mission, 1322 18th St., N. W., Washington, D. C.
8 Delta Section, AIME. Problems of offshore drilling.
8 East Texas Section, AIME.
8-11 Industrial Minerals Division, AIME, Tampa, Fla.
9 El Paso Metals Section, AIME.
9 San Francisco Section, AIME.
9 New York Section, AIME. Ladies Night. C. Goodman on "Atomic Energy."
10-11 National Air Pollution Symposium, Huntington Hotel, Pasadena, Calif.
10-14 ASTM, first Pacific area national meeting, San Francisco, Calif.
11-12 Central Appalachian Section, AIME., and W. Va. Coal Mining Inst., Summit Hotel, Uniontown, Pa.
11 Rio de Janeiro Section, AIME.
12-14 Geological Society of America, annual meeting, Hotel Cortez, El Paso.
14 Arizona Section, AIME, annual meeting, Pioneer Hotel, Tucson.
15 Gulf Coast Section, AIME.
15 Washington, D. C., Section, AIME.
16 Southwest Texas Section, AIME.
16-18 Industrial Hygiene Foundation, 14th annual meeting, Mellon Institute, Pittsburgh.
16-18 Geological Society of America, annual meeting, Hotel Statler, Washington, D. C.
17 Carlsbad Potash Section, AIME.
17 Utah Section, AIME.
28-Dec. 3 22nd Exposition of Chemical Industries, New York City.

DECEMBER

4-7 AIChE, national meeting, Pittsburgh, Pa.
7 American Mining Congress, Annual Business Meeting, New York City.
7-9 Eighth Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.
8-10 Seventh Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.

JANUARY 1950

18-20 American Society of Civil Engineers, annual meeting, New York.
30 AIEE, winter meeting, New York.

FEBRUARY 1950

10 Southwestern Section, Open Hearth Steel Committee, Iron and Steel Division, St. Louis, Mo.
12-16 Annual Meeting, AIME, Statler Hotel, New York City.

APRIL 1950

4-7 Nat'l Assn. of Corrosion Engineers, St. Louis.
10-12 Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Netherlands Plaza Hotel, Cincinnati.
19-21 American Society of Civil Engineers, spring meeting. Los Angeles.
23-26 American Ceramic Society, annual meeting, New York City.
24-26 AMC Coal Convention, Netherlands Plaza Hotel, Cincinnati, Ohio.

DECEMBER 1950

7-9 Electric Furnace Steel Conference, Iron and Steel Div., Hotel William Penn, Pittsburgh.

APRIL 1951

2-4 Open Hearth and Blast Furnace, Coke Oven and Raw Materials, Conference, Iron and Steel Division, Statler Hotel, Cleveland, O.

Daniel A. Jones is employed by the Territory of Alaska as assayer and mining engineer at the Nome assay office. Most of the summer was spent in examinations and examining samples to assay during the winter. It is his job to help further in every way possible the mining industry in northwestern Alaska.

Peter Joralemon completed his studies at Harvard, receiving a doctor's degree in geology, and is now working as a geologist for Getchell Mine, Red House, Nev.

Lou D. Jordan, formerly general superintendent of the Consolidated Mines for the Benguet Consolidated Mining Co. in the Philippines, has returned to the Western Hemisphere to work for the San Francisco Mines of Mexico at San Francisco del Oro, Chihuahua.

Thomas F. Kearns was reelected last May as president of the Silver King Coalition Mines. At the same time, **James Ivers** became vice-president and general manager, and **M. G. Heitzman** took over as manager of operations.

L. Russell Kelce of Kansas City has been elected to serve as a director of the National Coal Association. Mr. Kelce recently became president of the Sinclair Coal Co., and has been with that Company since 1924.

John M. Kerr is now serving as general manager of the Berwind-White Coal Mining Co. in Windber, Pa., thus moving up from his former post as general superintendent.

Daniel N. Klemme can be reached at the Hancock Oil Co. of California, 2828 Junipero, Long Beach, Calif.

R. P. Kinkel has resigned as manager of Buffalo Ankerite Gold Mines, Ltd., S. Porcupine, Ont.

Mack C. Lake has been appointed consulting engineer exclusively for the Oliver Iron Mining Co. and other U. S. Steel Corp. subsidiaries. He will deal largely with the company's ore developments in foreign fields.

Stanley Lefond is working for the Mene Grande Oil Co., Apartado 234, Maracaibo, Venezuela.

W. D. Lowry, until recently a geologist with The Texas Co. in California, has joined the staff of Virginia Polytechnic Institute, Blacksburg, Va., as associate professor of geology.

Robert C. McCain is working for the Frontier Refining Co. as an assistant geologist. Mail reaches him at Box 574, Durango, Colo.

I. H. McLean has taken up an appointment as a mining engineer in India and is addressed care of Agent, Central Provinces Manganese Ore Co., Nagpur, C.P., India.

Morris M. Menzies received his degree in geological engineering from the University of British Columbia, Vancouver, last spring, worked as a junior geologist for the Hudson Bay Mining and Smelting Co., and returned to Vancouver for post-graduate work this fall.

Paul Klempner

Paul Klempner and his wife recently arrived from Johannesburg, South Africa, for an extended tour of the United States. Mr. Klempner is a consulting engineer and just prior to his departure from South Africa he designed and supervised the erection of an asbestos plant and completed a number of surveys including reports on manganese, chromium, tungsten, and gold deposits.

Charles S. Merriam has been appointed head of the Solid Fuels Branch of the Mining and Geology Division, Natural Resources Section, SCAP, replacing **Daniel J. Carroll,** who has been transferred to the Economic and Scientific Section of SCAP as supervisor of coal production. The two men will co-ordinate the efforts of the two sections to keep coal production up, as well as to improve coal cleaning and preparation, use of mechanical equipment so far as is possible and to better utilization in Japan.

Pomeroy C. Merrill has left his post with the Eastern Mining and Metals Co. in Malaya. An attack of pneumonia forced him to take the first boat back to the States. **Robert E. Tally, Jr.,** has taken over his job.

Hugh D. Miser, of the U. S. Geological Survey, nationally known expert on petroleum geology, received the degree of Doctor of Laws at the 75th commencement of the University of Arkansas. The citation read: "your devotion to science and your high standards of scholarship and research have been a constant source of inspiration. You have explored many unknown paths of knowledge."

James W. Morgan became vice-president and general manager of the Ayrshire Collieries Corp. on Sept. 1. Connected with the coal industry since he graduated from Lehigh in 1921, he worked for C. A. Hughes & Co. until accepting the post of assistant to the vice-president in charge of operations of Truax-Traer's Eastern mines in 1948.

Alexander R. Mutch, formerly a student at Otago School of Mines, has the job of assistant geologist on a coal survey with the New Zealand Geological Survey, Balclutha, N. Z.

E. N. Pennebaker expects to be in South Africa until the end of the year reviewing geological and exploration problems for the O'okiep Copper Co.

J. S. Peterson and his wife are on a round-the-world pleasure trip and will spend the remainder of the year in the States on business and vacation. Mr. Peterson is vice-president and assistant general manager of the Benguet Consolidated Mining Co., Baguio, P. I.

R. E. O'Brien, who had been with the Mountain City Copper Co., is working for the Anaconda Copper Mining Co. at Conda, Idaho.

H. Gordon Poole, who had a year's leave of absence from his post as professor of mining engineering at the University of Washington, is returning from Mexico City where he was attached to the American Embassy as a mining and metallurgical consultant of the Bureau of Mines to the Mexican Government.

H. N. Propp has been made assistant district manager, central territory, crusher and process machinery division, Nordberg Mfg. Co. He has transferred to Milwaukee, Wis., from the San Francisco district office where he served as sales engineer for the past year.

Norman Phillips recently joined the chemical laboratory staff of the research and development department of the Babcock & Wilcox Co. in Alliance, Ohio.

James Quigley has completed a month's study of the Marysvale, Utah, uranium district for the Centennial Development Co. **Harold B. Spencer** is president of Centennial and is in charge of the Company's shaft sinking and tunnel driving activities.

P. H. Reagan, consulting mining engineer of Hye, Texas, returned from Nicaragua and has gone to Western Australia. He expects to return to his office in December.

Robert St. Clair is employed by the Carnegie-Illinois Steel Co. at their

Ohio district works as a process engineer.

Raymond E. Salvati, operating vice-president of the Island Creek Coal Co., was elected president of the Boston, Mass., Company at the June meeting of the board.

H. Sano, who retired as professor of the College of Engineering at Tokyo Imperial University to act as director of the Coal Board, is now Emeritus Professor at the University. As director of the Coal Board he endeavored to increase coal production in Japan in co-operation with officials of the Allied Powers, among whom he found many AIME members.

Hans H. Schou can be reached at the Frontino Gold Mines, Ltd., Segovia, Antioquia, Colombia.

George P. Schubert, since the closing of the Copper Range Smelter, has taken over as professor in charge of shops and drawing at Michigan College of Mining and Technology.

Munshi Lal Sethi has been minerals adviser to the Government of Jaipur since February. Eighteen different Indian States have formed the new province of United States of Rajasthan, covering an area of about 125,000 sq mi. In June Mr. Sethi received appointment as director of mines and geology to this new province in addition to his duties as minerals adviser.

Joseph G. Sevick graduated from the Missouri School of Mines in May and has become associated with the research department of the zinc division of the St. Joseph Lead Co., Monaca 7, Pa. He lives at 1200 Penn Ave., New Brighton, Pa.

A. Ben Shallit has been appointed superintendent of Carbonate Mines, Inc., Bald Butte, Mont.

James C. Shields, II, since last November has been doing geological field work in Cuba, practically all in Oriente Province. He is resident geologist for Geological Engineering Consultants (Cuba), Inc., in Havana.

Carl W. Sinclair retired from the staff of John A. Roebling's Sons Co. on July 1. He can be reached now at the Galigher Co., 545 W. 8th S., Salt Lake City 8.

L. E. Sinclair has resigned from Mount Isa Mines, Ltd., to go to New Caledonia, where he will be in charge of Establissement Baelande's mining interests in that island.

James T. Smith, who had been studying at the University of British Columbia, can be reached in care of Roan Antelope Copper Mines, 64 East Rand, Luanshya, N. Rhodesia.

Francis B. Speaker has transferred to the New York City office of Hewitt-Robins, Inc. As field engineer he will work out of the New York office for both Robins conveyors division and Hewitt rubber division.

Carsten Steffens has resigned as assistant director of Stanford Research Institute to take the post of associate professor of chemistry at the University of New Mexico in Albuquerque.

A. George Stern, former chief of the western research division of the Westvaco Chlorine Products Corp., is Pacific Coast manager of the Heyden Chemical Corp., San Francisco. His home address is 764 Forest Ave., Palo Alto, Calif.

Edward M. Thomas

Edward M. Thomas heads the Bureau of Mines newly established roof-control section of the health and safety division; the section will further the attack on the No. 1 killer in the nation's coal mines, falling rock and coal. While a major project of the new section is the adaptation of suspension roof support to more general use in mining, it will attack all phases of the roof-control problem through education, investigation, and research.

John K. Stewart is an engineer in training with Hollinger Consolidated Gold Mines Ltd., Timmins, Ont. His address in Timmins is 11 James Ave.

H. W. Straley, III, consulting geological and geophysical engineer, after spending a year in eastern Oklahoma has moved his office from Friendship Station, D. C., to Box 68, Princeton, W. Va. Temporarily he may be reached at 1459 Cameron Terrace, Drury Hills, Atlanta, Ga.

H. S. Taylor, who has been general counsel and vice-president in charge of mining operations, is the new president of the 95-year old iron ore, coal, and lake shipping concern, Oglebay, Norton and Co. Mr. Taylor was engaged in law practice for several years before joining the Company and is active now in many associations.

Alberto J. Terrones L., after spending a 4½ month leave in Mexico visiting operations there, returned to the Cerro de Pasco Copper Co. and his new job of geologist of the Cerro de Pasco division.

Gustave W. Voelzel and his wife made a six week trip this summer through Canada and New England. They visited AIME headquarters in New York City and returned to El Paso, Texas, by way of Niagara Falls.

J. K. Whatmough was appointed mine manager of Starratt Olsen Gold Mines, Ltd., Madsen, Ont., on June 1.

J. A. Willcox has a job with the Polaris-Taku Mining Co. in Tulsequah, B. C.

Alexander N. Winchell, after an interesting year as visiting professor of geology at the University of Virginia, has returned to his home at 88 Vineyard Rd., New Haven, Conn., where he will resume his editorial and consulting work in the field of mineralogy and crystallography.

P. F. Yopes is employed as a mining engineer with the safety division of the Bureau of Mines, working out of the Seattle office.

—In the Metals Branch—

Edgar C. Bain, vice-president in charge of research and technology at the Carnegie-Illinois Steel Co., will have two medal-receiving days in October. On the 19th he will get the John Price, Wetherill Medal of the Franklin Institute of the State of Pennsylvania, awarded for discovery or invention in the physical sciences or for new and important combinations of principles or methods already known. On Oct. 20 he will receive the Gold Medal of the ASM (see September Personals).

C. G. Benson, who has been with General Electric since graduation from Harvard, helped set up the Company's new plant in Brockport, N. Y. The major portion of his work has been in manufacturing methods and plant layout, with some specializing in plastic molding.

John O. Cartledge recently was promoted from the post of shift superintendent to assistant works metallurgist at the Port Pirie works of the Broken Hill Associated Smelters Pty. Ltd.

R. H. Covington has changed his address from the American Zinc Co. of Illinois, Dumas, Texas, to the

American Zinc Oxide Co., P. O. Box 327, Columbus 16, Ohio.

H. R. Dahlberg has left his post as assistant professor of industrial engineering at Oregon State and has joined the Twin City Testing and Engineering Laboratory as supervisor in the mechanical and metallurgical department in St. Paul, Minn.

Reginald S. Dean, metallurgical engineer and consultant of Washington, D. C., has moved his offices to 6000 34th Place, N.W., Washington 15. Dr. Dean is also president of R. S. Dean Laboratories, which has just moved into its own laboratory and office building at 5810 47th Ave., Riverdale, Md., just outside Washington.

Robert A. Eastman has the job of chemist at the Great Falls reduction works of the Anaconda Copper Mining Co. He can be reached at 821 3rd Ave. S.W., Great Falls, Mont.

John E. Gaus has left the ranks of metallurgists to enter the broader field of the entire mineral industries as curator of the Mineral Industries Museum at Penn State.

Robert E. Hagen is working in the research laboratory of the Oliver Iron Mining Co. in Duluth, Minn.

E. Hartshorne has transferred to New Haven, Conn., where he is assistant director of research and development for Winchester Repeating Arms Co., division of Olin Industries.

Robert H. Jacoby is chief metallurgist of the Key Co., 2700 McCasland Ave., East St. Louis, Ill.

T. G. Johnston, Jr., after receiving his degree in metallurgical engineering from Purdue in June, accepted the job of junior metallurgist in the metallurgical department of the National Tube Co. in Lorain, Ohio.

Jerome W. Kaufman, a recent Lehigh graduate, has a job as metallurgist at the Naval Air Material Station, Johnsville, Pa.

William C. Leslie, who has been a student at Ohio State, is working in the research laboratory of the U. S. Steel Corp. at Kearny, N. J.

Francis F. Lucas has retired from the Bell Telephone Laboratories. He can be reached at his home, 245 Rutledge Ave., East Orange, N. J.

N. E. Nilsen has been promoted to chief general manager of the Emperor, Loloma and Dolphin Mining Companies, with headquarters in Melbourne, Australia. Former general manager of the companies' properties at Vatukoula, Fiji, he will spend about half his time there.

Elliott S. Nachtman has been named instructor in metallurgical engineering at the Illinois Institute of Technology. He had served as a chemist for the Harshaw Chemical Co. and held a similar job with the Argonne National Laboratory.

Donald M. Liddell catches up with the news; the man behind him is unknown.

Donald M. Liddell returned to New York City in August after a 2½ months' professional trip to England and the Continent, which included participation in the Empire Mining and Metallurgical Congress.

Eric G. Peterson

Eric G. Peterson has been appointed general manager of the Peabody Engineering Corp., New York City, and will continue as general sales manager of all the Company's products in all divisions. Already known as one of industry's leading designers of combustion equipment, Mr. Peterson's new duties will broaden his supervision and interest to include the activities and welfare of all the Peabody offices and subsidiaries throughout the world.

Fred D. Rosi, formerly at the Hammond Metallurgical Lab., Yale, is now reached at the Research Laboratories, Sylvania Center, Bayside, L. I., N. Y.

John W. Pugh is with the General Electric Co., Rm. 522, Bldg. 5, Schenectady, N. Y.

Waldemar P. Ruemmler has succeeded **G. E. Johnson** as manager of the East Chicago plant of the Eagle-Picher Co. He joined Eagle-Picher in 1948 and has been successively in charge of research and development, and acting superintendent at East Chicago. Prior to this affiliation he was associated with Battelle Memorial Institute.

Edgar Sengier, managing director and chairman of the executive committee of Union Miniere du Haut-Katanga, has been honored by the French Government with the order of Commander of the Legion of Honor. This high decoration, together with the U. S. Medal for Merit and the Commander of the British Empire previously conferred, are in recognition of the outstanding services rendered by Mr. Sengier during the war years to Belgium's three great allies.

Morris A. Steinberg has been made a member of the board of directors of Horizons, Inc., of Princeton, N. J., and Cleveland, Ohio. The war had interrupted his studies, but after receiving his doctorate in physical metallurgy in July of 1948 he joined Horizons, Inc., and in March 1949, was appointed head of the metallurgy division.

John E. Stukel, Jr., has joined the operating department of the Youngstown Sheet and Tube Co. as a development engineer. He was assistant professor at Carnegie Institute of Technology.

John M. Thomas, research associate at the University of Michigan, has a new address at 3147 Vassar St., Dearborn, Mich. He is metallurgical engineer with the Hoskins Mfg. Co., of Detroit.

George H. Thurston, formerly with American Smelting and Refining at Selby, Calif., is now metallurgist with the Hall-Scott motor division, ACF-Brill in Berkeley.

William V. Ward, who has been with the Division of Industrial Cooperation at MIT doing research work sponsored by the Atomic Energy Commission during the summer, plans this fall to enroll in the graduate school at MIT to start work towards the degree of science doctor in metallurgy. His wife and son accompanied him to Massachusetts from the University of Arizona with which he was connected in a student-instructor capacity. Their new address is 349 Westgate West, Cambridge, Mass.

W. E. Mahin

W. E. Mahin, chairman of metals research at Armour Research Foundation of the Illinois Institute of Technology, has been named director of research. He heads a group of 411 scientists, engineers, and technicians who are working on 125 active research projects for industrial and government sponsors. For ten years previous to his joining the Research Foundation in 1947, Mr. Mahin was in charge of metallurgical engineering at the Westinghouse Electric Corp., Pittsburgh.

Ervin E. Underwood, after obtaining his B.S. degree in metallurgical engineering at Purdue, has moved to MIT for graduate work in their school of metallurgy.

B. H. Wadia has gone to Oroya, Peru, to work for the Cerro de Pasco Copper Co.

—In Petroleum Circles—

Roy F. Beery, Jr., formerly with the Shell Oil Co., has become division superintendent for the Danciger Oil and Refining Co., Norman, Okla.

George W. Burgess, junior exploitation engineer with the Shell Oil Co., can be reached in care of the Company, Box 488, Denver City, Texas.

Robert A. Coleman is a petroleum engineer trainee with the Gulf Oil Corp., with a mailing address at General Delivery, Kermit, Texas.

James Terry Duce is now residing in New York City, having moved from Washington, D. C., when executive offices of the Arabian American Oil Co., of which he is a vice-president, were established in the former city.

Thomas M. Esmond, who graduated from Texas Tech with a B.S. degree in petroleum geology last May, is employed by R. C. Lipscomb Oil Producer in San Antonio, Texas, as a geologist.

Martin Felsenthal joined the Continental Oil Co at Ponca City, Okla., on Aug. 1, to work as research engineer in the production laboratory of the Company's research and development department. Recently he received his M.S. degree in petroleum engineering from Penn State.

Lester S. Grant went into full retirement as vice-president of the Franco Wyoming Oil Co. and vice-president and manager of McElroy Ranch Co. on June 1. In July he and Mrs. Grant made a three week pleasure trip to Alaska and expect to attend the 75th anniversary of the Colorado School of Mines. He can be reached care of McElroy Ranch Co., Box 912, Midland, Texas.

Diego Henao-Lindoño is with the Servicio Geológico Nacional de Colombia, Bogota, as a geologist.

Herbert A. Koch

Herbert A. Koch, general sales engineer for Dowell Incorporated in Tulsa, has been appointed head of the Fort Worth, Texas, office. Sales co-ordinator in the Fort Worth-Dallas area, he will have special responsibilities throughout Texas, Louisiana, and New Mexico. An alumnus of the University of Oklahoma, Mr. Koch has been with Dowell since 1944 and has received special training with the Company in electric pilot services.

Bart W. Gillespie is general manager for the Mexican American Independent Co., Reforma No. 1, Despacho 204, Mexico, D.F., Mexico.

William R. Goodier, formerly associated with the Shell Oil Co. in Great Bend, Kans., is now employed by the Barnsdall Oil Co., Newhall, Calif., as a petroleum engineer.

J. T. Holten, Jr., recent graduate of the University of Oklahoma, is working as an engineer for the Mid-Continent Petroleum Corp., Seminole, Okla.

M. King Hubbert, associate director of research of the Shell Oil Co. exploration and production research laboratory, served as a U. S. delegate to the United Nations Scientific Conference on Conservation and Utilization of Resources held at Lake Success, N. Y., Aug. 17 to Sept. 6.

Robert K. James is working at Eunice, N. Mex., as a petroleum engineer trainee with the Magnolia Petroleum Co.

Howard F. Johnston, district geologist for the Quaker State Oil Refining Corp., has been transferred from Newark, Ohio, to the newly opened production offices at Parkersburg, W. Va.

Paul S. Johnston has taken the post of professor of petroleum engineering at Texas Technological College, Lubbock, Texas.

Norris Johnston has been named president of the consulting firm Petroleum Technologists, Inc., in Montebello, Calif. For the past ten years he had been chief physicist in charge of production research for the General Petroleum Corp. During this period he was assigned to Socony-Vacuum to set up their Dallas production research laboratories.

Gordon H. White recently resigned from the Shell Oil Co. to join the ranks of the independent operators. He has incorporated his own company under the name of the Niles Oil Co., with headquarters at 1406 M & W Tower Bldg., Dallas, Texas. His work with Shell had taken him to many of the oil producing areas

Gordon H. White

of this country; in 1938 he was sent to the Hague, Holland, returning to the Houston office in mid-1939.

Eugene L. Davis, formerly general production superintendent for the Signal Oil and Gas Co., Los Angeles, has accepted the post of project manager of the Arctic Contractors,

Eugene L. Davis

Fairbanks, Alaska. The Arctic Contractors, under contract to the Navy, are conducting oil exploration activities in Naval Petroleum Reserve No. 4, Point Barrow, Alaska.

M. C. Leverett joined the NEPA (nuclear energy for the propulsion of aircraft) project at Oak Ridge, Tenn., as its technical director in June. The NEPA project is a division of the Fairchild Engine and Aircraft Corp. and its work is under the U. S. Air Forces. Mr. Leverett was formerly research associate with the Humble Oil and Refining Co.

Arthur Maddox has been transferred from the International Petroleum Co., Barcelona, Venezuela, to the Carter Oil Co. in Tulsa, Okla.

Melford F. Rabalais has changed his mailing address to Kerr-McGee Oil Industries, Inc., Sunray, Texas.

Glenn Nelle has joined the General Petroleum Corp. as assistant manager of Rocky Mountain operations. Mr. Nelle had been in Venezuela with Socony-Vacuum.

E. E. Rehn has announced his resignation as division geologist of the Western Division of the Sohio Petroleum Co., and is returning to Evansville, Ind., to open consulting geological offices at 308 Grein Bldg.

Bruce H. Sage, professor of chemical engineering at California Institute of Technology, was given the new $1,000 Precision Scientific Co. award in petroleum chemistry at the recent national meeting of the American Chemical Society. He is credited with having significantly enlarged the recoverable natural oil resources of the country during his nineteen years of research.

N. van Wingen, professor of petroleum engineering of the University of Oklahoma, has resigned to join, as vice-president, the consulting firm, Petroleum Technologists, Inc., in Montebello, Calif. Prior to joining the University staff, he had been associated for nine years with the Richfield Oil Corp.

Herbert N. Wade is with The Texas Co. in Buckeye, N. Mex., as an engineer trainee.

Theodore G. Ward, Jr., has taken the job of junior engineer with the Atlantic Refining Co., Dallas, Texas.

David B. Wilke, Jr., after graduation from the University of Kansas with a B.S. degree in petroleum engineering, was employed by the Skelly Oil Co. He is working in their New Mexico district and can be reached at Drawer D, Hobbs, N. Mex.

Walter L. Williams is an engineer trainee with American Republics Corp., Silsbee, Texas. His address there is P. O. Box 451.

Obituaries

Charles Worth Fowler, Jr. (Member 1942), president of United Oilwell Service, Caracas, Venezuela, died Sept. 30, 1948. He was 49 years old. Most of Mr. Fowler's career was spent in Mexico and South America;

Charles W. Fowler, Jr.

he had been with the Mexican Gulf Oil Co., Yacimientos Petroliferos Fiscales, Argentina, and the Pantepec Oil Co. of Venezuela. He was also a junior member of Brokaw, Dix, Garner & McKee.

Paul Armitage (Member 1918), noted corporation lawyer and an expert in taxation practice, died on June 28. Mr. Armitage was a member of the law firm of Armitage and Holloway in New York City, which firm had been counsel to the Woolworth Estates, the United Verde Extension Mining Co., the G. R. Kinney Co., to name but a few. Mr. Armitage graduated from Columbia University in 1894 and from Columbia's Law School two years later. He was admitted to the bar in the same year, and, in 1905, admitted to practice before the U. S. Supreme Court.

Mr. Armitage, a champion figure skater in his youth, was a founder of the New York Skating Club. He was also a member of the Academy of Political Science, the American Bar Association, and a director of a number of firms.

Percy A. E. Armstrong (Member 1924), a leader in the development of stainless steel, died on Aug. 7 after a long illness. Born and educated in England, he came to this country 30 years ago. Nationally recognized for his work in metallurgy, he was an early developer of stainless steel and held more than 100 patents on steel alloys. Mr. Armstrong was a vice-president and general manager of the Allegheny Ludlum Steel Co.

William Albert Baueris (Member 1936), mining engineer of Seattle, Wash., died on Feb. 23 at the age of 65. Mr. Baueris had a long and varied career in exploration, mining, construction, and manufacturing. It began in 1900 when he worked for five years as a structural draftsman and field superintendent for the Chicago Bridge and Iron Works. In 1909, he graduated from the Missouri School of Mines, did some geological reconnaissance, worked in the Homestake mine for a year, and then spent twelve years with the Puget Sound Bridge & Dredging Co. in Seattle. From 1922 to 1925 his were various activities associated with gold mining, and 1936 found him examining Bonanza Creek and Ungalik River deposits in the Norton Sound area of Alaska. Later, he headed the Ungalik Syndicate, finally retiring in 1942.

William Bell (Member 1936), of Robinson, Ill., is dead. Mr. Bell, who was born in Franklin, Pa., on Aug. 29, 1874, had been an independent owner and operator of oil producing properties in Pennsylvania, West Virginia, Indiana, and Illinois, for the past 50 years.

Necrology

Date Elected	Name	Date of Death
1897	Thomas J. Barbour	Unknown
1914	Z. T. Crittenden	March 25, 1949
1946	Henry Davenport	Unknown
1933	Carl Erickson	June 28, 1949
1919	Charles T. Evans	May 13, 1949
1938	Dwight H. Fortine	Aug. 3, 1949
1944	Russell J. Parker	Sept. 9, 1949
1928	R. C. Patterson	April 3, 1949
1920	E. T. Stannard	Sept. 9, 1949
1926	Arthur D. Storke	Sept. 9, 1949
1939	W. W. Taylor	Unknown
1920	C. Erb Wuensch	Aug. 27, 1949

Walter Frederic Bart Berger (Member 1907), died on June 6. Born in Denver in 1877, he attended the Colorado School of Mines for a year after graduating from Yale. He spent some time in Japan for the Chipman Chemical Co. and upon his return opened an office in New York City. He later moved to Denver to form the partnership of Berger & Sayre, mining engineers, and subsequently practiced independently. In recent years his home was in Victoria, B. C.

Walton Ambrose Bishop (Member 1945), died on June 10. He was 73 years old. Mr. Bishop had been with the Pocahontas Fuel Co., in Pocahontas, Va., for the past 43 years, and when he died, was the firm's chief engineer. Mr. Bishop was born in Snowville, Va., and was familiar with "Snowville wood, iron, steel, textile and grain mill machinery, from childhood." He was, for two years, operating engineer for the Radford Light and Power Co., then worked as an electrical engineer with the Virginia Iron Coal and Coke Co. before joining Pocahontas, in 1901.

Thomas Clark Botterill (Member 1942), died on June 15, at the age of 56. Mr. Botterill was a Canadian citizen although he was born at Rock Springs, Wyo. He pursued various studies in civil and mining engineering, and began his career as a draftsman in 1907. The next 25 years found him working as an engineer or superintendent on 12 different Canadian mining properties, including the Brittania Mining and Smelting Co., the Pacific Construction Co. In 1932 he formed his own consulting business, and from 1932 until his death his activities included both consulting and management work for numerous firms in British Columbia. His last position was managing director for the Hedley-Monarch Gold Mines in Vancouver.

John R. Comstock (Member 1920), general superintendent of the Pittsburgh Coke & Chemical Co. since Dec. 20, 1943, died suddenly July 14, 1949, at the Neville Island plant of the Company.

Mr. Comstock's outstanding personality and long association in the Merchant Blast Furnace field had given him a host of admiring friends and a national reputation in blast furnace operation.

A graduate of Stevens Institute of Technology in 1911 with a mechanical engineering degree, Mr. Comstock started his steel experience with the Pennsylvania Steel Co. at Steelton, where he became assistant superintendent of blast furnaces. In 1921 he was made assistant general manager of the Hanna Furnace Co. at Cleveland, and served in that capacity until 1931. In 1933 he was appointed general superintendent of the Globe Iron Co. at Jackson, Ohio, until 1943 when he became associated with the Pittsburgh Coke & Chemical Co. He was 58 years old at the time of his death.

George Bradstreet Dodge (Member 1939), vice-president of the American Rubber Mfg. Co., San Francisco, died in 1948. Born in Waukeegan, Ill., in 1880, he held various posts in the East and in 1906 became vice-president of the Western Belting Hose Co., the Lightning Hose Rack Co. and American Rubber, which later absorbed Western and Lightning.

Louis W. Huber

Louis W. Huber (Member 1937), vice-president of the National Mine Service Co., died Aug. 17, 1949. The suddenness of his death was a distinct shock to his many friends and associates in many mining fields of the country.

Born in Paris, Ill., May 13, 1899, his mining experience began early in life when he was but 15 years of age. He did everything there was to do in the underground operation of a coal mine from trapping and driving mule, on through coal loading, timbering, undercutting, electrical and mechanical repairs, maintenance, to face bossing in order to pay his own way through high school and college. All this practical underground work stood him in good stead later in life.

For two years after graduating from the University of Illinois in mining engineering in 1921, Mr. Huber was engaged in research work on mine ventilation and part-time teaching at his Alma Mater. Then he took the job of mine ventilation engineer in the Midwest for the B. F. Sturtevant Co. The fall of 1924, he joined the faculty of Carnegie Institute of Technology to teach mining engineering in the department of mining and metallurgy.

Four years later he became associated with Mine Safety Appliances Co. as sales representative in Cincinnati, Ohio, and steadily progressed in his work and responsibilities to become district manager. His service with this company extended over a period of 20 years, from 1928 to 1948.

On May 1, 1948, Mr. Huber was elected vice-president of National Mine Service Co. in charge of its two divisions in Kentucky, and all field operations and representatives in the states of Kentucky, Tennessee, Illinois, and Indiana. His home and headquarters for many years were in Lexington, Ky.

A foremost authority on mine ventilation, his services as a consultant were widely sought. In safety work, he served untiringly, and he was known throughout the country for his active participation and leadership in rescue work following many mine disasters.

Tore Flygare (Member 1947), Swedish mining engineer, died in November, 1947. Mr. Flygare, who had an E.M. degree from the Royal University of Technology in Stockholm, had been with Philippine Iron Mines for four years. In 1941 he joined the International Engineering Corp. in Manila, and at the time of his death was working with the Boliden Mining Co. in Boliden, Sweden.

Emil Gathmann (Member 1913), president of the Gathmann Engineering Co., the Gathmann Research Laboratories, Cantonsville, Baltimore, Md., former head of the Bethlehem Steel Company's ordnance department, inventor of note, died on Aug. 23. Holder of more than 100 patents for various types of metal he developed, he had invented a type of depth bomb to be used against submarines; many of his patents related to naval ordnance, particularly for fuses. A native of Chicago, where he was born in 1874, Mr. Gathmann went to Baltimore in 1909 after starting an engineering firm in New York.

Virgil O. Harris (Member 1943) is dead. Born at Bison, Okla., in 1907, he took his B. S. degree from Oklahoma University. Following graduation he joined the staff of the Humble Oil and Refining Co., with which he was associated at the time of his death.

Joseph Samuel Henry (Member 1918), mining engineer of Castlemaine, Vic., Australia, died on March 26. He was 73 years old at the time of his death. He received his technical education in Australia,

at the Technical College of Geelong in Victoria, worked for a time in London, and then was engaged in tin dredging operations in Siam and Australia. In recent years, before his retirement, he was a consulting engineer to the Austral Malay group and other companies "down under."

William D. Mark

An Appreciation By W. W. LYTZEN

William D. Mark (Member 1928), aged 44, mining engineer for the RFC, died suddenly of a heart attack on June 16 at his home in Chevy Chase, Md.

Bill joined the geological department of the Anaconda Copper Mining Co. at Butte, after graduating from the Idaho School of Mines, and in 1933 went to South America with the Cerro de Pasco Copper Co. as a geologist. Upon his return to this country he joined the RFC as field representative in Boise, Idaho, and Spokane, Washington, and for the past 13 years has been with the Washington Office of that Corporation.

Bill Mark was highly regarded, not only for his great personal integrity, but also for his integrity and ability in his profession. His sudden death came as a shock to his associates and many friends.

Walter Miller (Member 1918), of Ponca City, Okla., is dead. Mr. Miller was a vice-president of the Continental Oil Co. in that city. Born in Switzerland in 1881, Mr. Miller had little formal education and worked, until 1909, as a machine hand, blacksmith's helper, bookkeeper, and cost accountant, at which time he joined the Tidewater Oil Co. in Bayonne, N. J. He began there as a clerk, and within eight years had advanced to process superintendent. In 1919 he became a consulting refining engineer in Tulsa, and two years later joined the Marland Refining Co. in Ponca City, as manager of manufacturing. In 1930 he went with Continental Oil.

Clarence J. Peterson (Member 1916), died on May 8. Born in Honolulu, T. H., in 1885, Mr. Peterson received an A.B. degree in geology and mining from Leland Stanford Junior University in 1910, and spent the first six years of his career doing exploration work in Venezuela for the Bermudez Co. of Trinidad, and as an examining mining engineer for the Tonopah Mining Co. in Nevada. He then served as a geologist with such firms as the Empire Gas and Fuel Co. and the Cities Service Gas Co. until 1930, when he joined the Texoma Natural Gas Co. in Amarillo, Texas, as chief geologist. He held this position at the time of his death.

Victor H. Wilhelm (Member 1921), Captain USNR, died at the Long Beach Naval Hospital on July 7 after an illness of several months. He was 63 years of age, graduated as a geologist and mining engineer

Victor H. Wilhelm

from Stanford University in 1907, and followed mining and oil all of his life. After some years spent in all of the western states, Mexico, Canada, and Alaska, he settled down in California and was one of the early petroleum engineers of the State, being well known as an engineer and deputy supervisor with the California State, Division of Oil and Gas, then known as the State Mining Bureau. He became chief petroleum engineer of the Old Petroleum Midway and California Petroleum Companies and continued as such when those companies became The Texas Co. He will be remembered by a host of friends as the sage of the local petroleum industry and for his friendliness, advice, and counsel given particularly to young geologists and engineers.

In February of 1941 he was called to active duty as Lieutenant Commander in the Naval Reserve in the Office of Inspector Naval Petroleum Reserves in California and rose to the rank of Captain. He remained on active duty at the close of the war and has been the Inspector of Naval Petroleum Reserves in California since 1944.

E. A. Cappelen Smith (Member 1904), noted expert on metal refining, and consulting metallurgical engineer with Guggenheim Brothers in New York City, died on June 25 at the age of 75. Mr. Smith originated the Guggenheim method of extracting nitrate from caliche, and an extraction process used at the Chiquicamata plant of the Chile Exploration Co. His development of a method of basic copper converting was instrumental in revolutionizing the copper-smelting industry.

Born in Trondheim, Norway, he graduated from the Technical College of Trondheim and came to the United States in 1893. He became a chemist for the Chicago Copper Refining Co., later served as superintendent of Anaconda's electrolytic copper refinery, metallurgical engineer for the Baltimore Copper Smelting and Rolling Co., and a consultant with ASARCO in New York. He joined the Guggenheim brothers in 1912. From 1925 to 1931 he served as president of the Anglo Chilean Nitrate Corp., managing 62 per cent of all Chilean nitrate production.

Mr. Smith was a director of the Chile Copper Co., and the Chile Exploration Co. He held patents on processes used in the development of selenium, telluvium, platinum, and palladium from electrolytic copper refining slimes. His distinguished work in hydrometallurgy earned for him the gold medal of the Mining and Metallurgical Society of America in 1920, the Norwegian decoration of Knight Commander with Star of the Order of St. Olaf, and Chile's highest civilian honor, Knight Commander of the Order "Al Merito."

Proposed for Membership

Total AIME membership on Aug. 31, 1949, was 15,870; in addition 4424 Student Associates were enrolled.

ADMISSIONS COMMITTEE

James L. Head, Chairman; Albert J. Phillips, Vice-Chairman; George B. Corless, T. B. Counselman, Ivan A. Given, Robert L. Hallett, Richard D. Mollison, and John Sherman.

Institute members are urged to review this list as soon as the issue is received and immediately to wire the Secretary's office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate; F, Junior Foreign Affiliate.

ALABAMA

Birmingham—DONOHO, CHARLES KERR. (C/S—J-M). Chief metallurgist, American Cast Iron Pipe Co.

ARIZONA

Hayden—ELROD, SAM D. (C/S—S-J). Junior engineer, Kennecott Copper Corp.

Superior—PELLETIER, JOHN DAVID. (R, C/S—S-J). Geologist, Magma Copper Co.

Tucson — MARVIN, THOMAS CROCKETT. (C/S—J-M).

ARKANSAS

Fayetteville—MATTHAEI, RICHARD. (C/S—J-M). General superintendent, Corona Silica Corp.
Malvern—SACKETT, EARL L. H. (C/S—J-M). Assistant division metallurgist, Baroid sales division, National Lead Co.

CALIFORNIA

Berkeley—SMITH, EMORY. (M). Supervising engineer, California State Division, Industrial Safety.
Chino—SHAFER, ROBERT ROY. (C/S—S-J). Engineer in training, Stanolind Oil and Gas Co.
Long Beach—O'NEILL, DONALD BAILEY. (C/S—S-J). Engineer trainee, Shell Oil Co.
Los Angeles—CROG, RICHARD STANLEY. (C/S—J-M). Research group leader, Union Oil Co. of California. HAYASE, MASASHI. (C/S—S-J). STERLING, MORTON ALAN. (C/S—S-J). Petroleum engineer, Eagle Oil and Refining Co.
North Hollywood—CABEEN, WILLIAM ROSS. (C/S—J-M). Owner, William Ross Cabeen and Associates.
Ojai—McENTEE, JAMES ROBERT. (C/S—J-M). Senior mechanical engineer, Shell Oil Co.
San Francisco—GRAY, EDWARD GORDON. (C/S—AM-M). Project engineer, Goldfield Consolidated Mines. VER PLANCK, WILLIAM EVERETT, JR. (C/S—J-AM). Junior mining geologist, California Division of Mines.
San Marino — HOPKINS, JOHN. (M). District manager, Kobe, Inc.

COLORADO

Climax — FROHLING, EDWARD SEBASTIAN. (C/S—S-J). Metallurgical testing engineer, Climax Molybdenum Co.
Denver—BAKER, CROSBY FRED, JR. (C/S—J-M). Chief chemist and metallurgist, American Smelting and Refining Co.
Ouray—GRIGSBY, HARRY GORDON. (C/S—S-M). Mill operator, Idarado Mining Co.
Sargents — DUNN, JAMES EDWARD. (C/S—J-M). Superintendent, Callahan Zinc-Lead Co.
Silverton — ARCHIBALD, JOHN ELLIS. (M). Partner and mine manager, Lead Carbonate Mines, Inc.

CONNECTICUT

Milford—SNYDER, JOHN ALDEN. (C/S—J-M). Research metallurgist, Remington Arms Co.

GEORGIA

Atlanta—COFER, HARLAND ELBERT, JR. (C/S—S-J). Teacher, Emory University.

IDAHO

Burke—POWERS, PHILIP PHINEAS. (C/S—S-AM). Surveyor, Hecla Mining Co.
Kellogg—HARDY, ROBERT MONROE. (AM). Assistant treasurer, Sunshine Mining Co.

ILLINOIS

Berwyn — HRADECKY, FRANK JOSEPH. (M). Chief draftsman, Open Hearth Combustion Co.
Brookfield — GRAY, VERNON MAX. (C/S—S-AM). Cast-house metallurgist, Reynolds Metals Co.
Chicago—HATCH, GERALD GORDON. (C/S—S-J). Research metallurgist, Armour Research Foundation.
Clarendon Hills—DUNN, RAY P. (C/S—J-M). Plant metallurgist, Doehler-Jarvis Corp.
Evanston—ANDERSON, WALTER WILLARD. (R, C/S—JA-M). Technical director, Western Division, Commercial Testing and Engineering Co.
Mt. Vernon—POMEROY, CHESTER MITCHELL. (C/S—J-M). Technical representative, explosives, E. I. du Pont de Nemours and Co.

INDIANA

Evansville — INGLE, WILLIAM DAVIDSON, JR. (C/S—J-AM). Combustion engineer, Ingle Coal Corp.
Gary — NAULT, WILLIAM ALFRED. (C/S—J-M). Metallurgist, Carnegie-Illinois Steel Corp.
Whiting—GRAVES, DONALD B. (C/S—J-M). Physical metallurgist, Federated Metals division, American Smelting and Refining Co.

KANSAS

Baxter Springs—HOCKER, RICHARD LESLIE. (C/S—S-J). Field engineer, Amerada Petroleum Corp.
Belleville—ARROWSMITH, MURRAY REX. (C/S—S-J). Mining geologist.
Burden—MORRIS, SAM J., JR. (C/S—S-J). Area engineer, The Texas Co.
Eureka — ARNOLD, EDWIN S. (C/S—J-M). Assistant district superintendent, Phillips Petroleum Co. WITHERSPOON, PAUL ADAMS, JR. (C/S—J-M). Reservoir engineer, Phillips Petroleum Co.
Gorham—EHLERS, PETER LEE. (J). Junior petroleum engineer, Stanolind Oil and Gas Co.
Independence — LEE, THOMAS WILLIAM. (M). Production superintendent, Union Gas System, Inc.

KENTUCKY

Lexington — ROLL, WILLIAM HAYDEN. (M). Mining engineer, Department of Mines and Minerals, Commonwealth of Kentucky.
Wheelwright—KURTYKA, JOHN CHESTER. (R, C/S—S-M). Engineer, Inland Steel Co.

LOUISIANA

Hackberry — SIMPSON, JOHN MILTON. (C/S—S-J). Petroleum engineer, Stanolind Oil and Gas Co.
New Orleans — GRAHAM, WILLIAM JOSEPH. (C/S—S-J). Petroleum engineer trainee, The Texas Co.

MARYLAND

Baltimore—HAYES, SELDEN C. (C/S—J-M). Superintendent, heat treating and pickling, rustless division, Armco Steel Corp.

MASSACHUSETTS

Waltham—CLEVENGER, GALEN WILLIAM. (C/S—J-M). Senior metallurgist, Division of Industrial Co-operation, MIT.

MICHIGAN

Ann Arbor—LANDES, KENNETH KNIGHT. (R, C/S—JA-M). Chairman, department of geology, University of Michigan.
Detroit — KLAPKA, KARL JEROME. (C/S—J-M). Field engineer, Wheel Trueing Tool Co.
Ishpeming—AHL, WAYNE JOHN. (C/S—S-J). Mining engineer, Inland Steel Co.

MINNESOTA

Duluth — WILLIAMS, MILTON FRIEL, JR. (C/S—J-M). Associate chemical engineer, Oliver Iron Mining Co.
Hibbing—SMITH, DAVID POST. (C/S—S-J). Mining engineer trainee, Oliver Iron Mining Co.

MISSISSIPPI

Durant—MOORE, JOHN P. (C/S—S-J). Junior exploitation engineer, Shell Oil Co.

MISSOURI

Flat River—MARR, CHARLES A. (C/S—S-J). Mining engineer, St. Joseph Lead Co.

NEW MEXICO

Albuquerque — GRISWOLD, GILBERT RIPLEY. (C/S—J-M). Mining engineer, George W. Potter.
Fierro—YOUNG, THOMAS WESLEY. (C/S—J-M). Foreman, U. S. Smelting Refining and Mining Co.
Los Alamos—CAMPBELL, GILBERT LEWIS. (C/S—J-AM). Project librarian, Los Alamos Scientific Laboratory. TIPTON, CLYDE RAYMOND, JR. (C/S—J-M). Physical metallurgist, University of California, Los Alamos Scientific Laboratory.
Monument — BRAKEY, ROBERT JAMES, JR. (C/S—S-J). Field engineer, Amerada Petroleum Corp.
Silver City — RICHMOND, KENNETH CLYDE. (R, C/S—S-M). Engineer-contractor, self-employed.
Vanadium—GLADSTONE, IRVIN. (C/S—J-M). Chief geologist, Bayard division, U. S. Smelting Refining and Mining Co.

NEW JERSEY

Morristown—FINE, MORRIS EUGENE. (C/S—J-M). Member, technical staff, Bell Telephone Laboratories.
Westfield — DAHLSTROM, ROY. (M). Technical director, Titanium division, National Lead Co. LAGERGREN, MILTON ANDY. (C/S—J-M). Design engineer, American Smelting and Refining Co.

NEW YORK

Bayside—RUBENSTEIN, HENRY S. (C/S—S-J). Research engineer, Sylvania Electric Products, Inc.
Brooklyn — MITILINEOS, JOHN DIMITRIOS. (C/S—S-J). Metallurgical engineer, American Platinum Works.

Flushing — ARNAUT, ARNOLD DOUGLAS. (C/S—S-J). Junior engineer, Sylvania Electric Products, Inc.
Hicksville — RACEK, EDWARD WILLIAM. (C/S—S-J). Petroleum engineer, Acme Well Supply Co.
Lewiston—EVANS, FRED LEROY. (C/S—J-M). Plant superintendent, U. S. Vanadium Corp.
Long Island City — LUTTER, FRANK WILLIAM. (C/S—S-AM). Service engineer, Hardinge Co.
New York—CAMPBELL, JOHN BARDO. (C/S—S-J). Associate editor, **"Materials and Methods,"** Reinhold Publishing Corp. FREUDENTHAL, ALFRED MARTIN. (M). Professor of civil engineering, Columbia University. MORGAN, DAVID E. (C/S—J-M). Consulting engineer; vice-president, International Manufacturing and Equipment Co.
Port Washington—DeVINCENTIS, HAROLD ANTHONY. (C/S—J-M). Project leader, Sylvania Electric Products, Inc.

NORTH CAROLINA

Asheville—HASH, LEWIS JACKSON. (C/S—S-J). Geologist, Tennessee Valley Authority.

OHIO

Ashtabula — MICKSCH, JOSEPH ERNEST. (C/S—S-J). Research engineer, Lake City Malleable, Inc.
Canton—ROWLAND, ELBERT S. (C/S—J-M). Research metallurgical engineer, Timken Roller Bearing Co.
St. Clairsville—JOSLIN, RICHARD EDWIN. (R, C/S—M-AM). Preparation, Hanna Coal Co.
Cleveland—BALDWIN, WILLIAM MARCH, JR. (C/S—J-M). Research professor, Case Institute of Technology.
Columbus — MILLER, CARL EDWARD. (M). Technical advisor, Battelle Memorial Institute.
Martins Ferry—BALCAR, FRANK A. (C/S—J-M). General manager, B. B. R. Drilling Co.
Springfield—HELMAN, DONALD DEANE. (C/S—S-J). Chief metallurgist, Ohio Steel Foundry Co.
West Middletown—WESTFALL, E. R. (M). Superintendent, masonry department, Armco Steel Corp.
Youngstown — STEIGNER, EDWARD SAMUEL. (M). Tubular products development engineer, Youngstown Sheet and Tube Co.

OKLAHOMA

Shidler—BENZ, LEWIS WALTER. (M). Assistant district superintendent, Phillips Petroleum Co.
Tulsa—HAMNER, FRANCIS MERRICK. (AM). Geological engineer, Schermerhorn Oil Corp. SHERMAN, HENRY ALVORD. (M). Production manager, Schermerhorn Oil Corp. WENGER, EVERETT SAMUEL. (C/S—J-M). Petroleum engineer, Amerada Petroleum Corp. WILSON, RALPH HERBERT. (C/S—J-M). Field laboratory supervisor, Shell Oil Co. WOLFF, PAUL ANTHONY. (M). Consulting engineer, Barnsdall Research Corp.

OREGON

Albany—DILLING, ELMER DONALD. (C/S—J-M). Metallurgist, U. S. Bureau of Mines.
Maupin—ROE, JOSEPH THOMAS. (C/S—J-M). Construction engineer, Dantore division, Dant and Russell, Inc.

PENNSYLVANIA

Allentown—CONSTANTIN, GASTON FRANCOIS. (C/S—J-M). Research engineer, Fuller Co.
Beaver Falls—SHEPPARD, RALPH EDGAR. (C/S—S-J). Research engineer, St. Joseph Lead Co.
Bridgeville—MARTIN, ROBERT EDWARD. (R, C/S—S-J). Demonstrator, Cardox Corp.
Clarksville—KING, THOMAS ANTHONY. (C/S—S-J). Section foreman, Westmoreland Mining Co.
Cornwall — SLEEMAN, ROBERT WARREN. (R, C/S—S-J). Head engineer, Bethlehem Steel Co.
Dalton — ROTH, WILLIAM BELFORD. (C/S—S-J). Student engineer, Hudson Coal Co.
Easton — BLANCO CARRANZA, NESTOR, (J). Junior field geologist, Socony- Vacuum Oil Co. of Colombia.
Lebanon — LAMBERT, KENNETH ALFRED, JR. (R, C/S—S-J). Engineer, Bethlehem Steel Co. PEETS, ROBERT G. (C/S—J-M). Chief mining engineer, Cornwall division, Bethlehem Steel Co.
New Kensington — HOLLINGSWORTH, ERNEST HOWARD. (C/S—J-M). Research metallurgist, aluminum research laboratories, Aluminum Co. of America.
Pittsburgh — EDDINGER, RALPH TRACY (C/S—S-M). Chemical engineer, Pittsburgh Consolidated Coal Co. MERRILL, TIMOTHY WARRINGTON. (C/S — J-M). Metallurgical engineer, Vanadium Corp. of America. PELLISSIER, GEORGE EDWARD. (C/S—J-M). Research associate, supervisor, physical and analytical methods, research laboratory, Carnegie-Illinois Steel Corp.
Pottsville—INGERSOLL, DALLAS EAST. (R—M). Division superintendent, Philadelphia & Reading Coal and Iron Co.
Scranton — FOSTER, RALPH KEELER. (R, C/S—S-J). Service engineer, Ingersoll-Rand Co.
State College — FREDRICKSON, JAY WARREN. (C/S — S-AM). Chief, division of metallurgy, School of Mineral Industries, Pennsylvania State College.
Washington — LUCAS, EUGENE FREDERICK. (C/S—S-J). Metallurgical engineer and chairman of works committee, Molybdenum Corp. of America.

SOUTH CAROLINA

Greenville—KELLEY, JOSEPH A. (C/S—J-AM). Division manager, Zonolite Co.

TENNESSEE

Memphis — PHELAN, STEPHEN RICE. (C/S—J-M). Geological and geophysical engineer, Stephen R. Phelan.
Rockwood — LUDWIG, ROBERT LEE. (J). Associate metallurgist, NEPA projects, Fairchild Engine and Airplane Corp.

TEXAS

Alice — CHILDRESS, CHARLES OTTO. (C/S—S-J). Petroleum engineer, Magnolia Petroleum Co.
Andrews — VOGEL, ALFRED J. (C/S—S-J). Assistant superintendent, Fuhrman Petroleum Corp.
Austin—BEAN, ERNEST F., JR. (C/S—J-AM). Student, University of Texas.
Beaumont — CHANEY, PRESTON EARL. (C/S—J-M). Research engineer, Sun Oil Co. DIBRELL, ETHERIDGE. (R, C/S—J-M). Reservoir engineer, Sun Oil Co.
Bellaire—OLIVE, MARION DOYLE. (J). Petroleum engineer, J. R. Butler and Co.
Brownfield — GOODWIN, GENE MERREL. (C/S—S-J). Production engineer, Magnolia Petroleum Co. RHOADS, BENJAMIN JUDSON, JR. (J). Junior petroleum engineer, Stanolind Oil and Gas Co. ROWE, MARTIN DECATUR, JR. (C/S—S-J). Petroleum engineer, Magnolia Petroleum Co.
Conroe—NORTON, CHARLES A. (C/S—J-M). Field foreman, The Texas Co.
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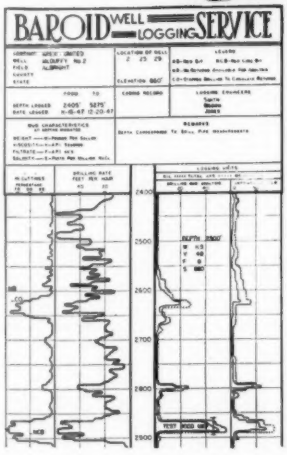

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THE RELATION BETWEEN ELECTRICAL RESISTIVITY AND BRINE SATURATION IN RESERVOIR ROCKS

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ABSTRACT

Data are presented which indicate that the saturation exponent, n, in the equation, $R_s = R_{100}S^{-n}$, relating core resistivity, R_s, to the resistivity at 100 per cent saturation, R_{100}, and to the saturation, S, may vary appreciably from the value of two which is usually assumed for this exponent when interpreting well logs. Values ranging from one to two and one-half have been found on core samples investigated to date. Attempts to correlate this saturation exponent with porosity or permeability of the core have not been successful. The saturation exponent is apparently not a function of the interfacial tension between the brine and the displacing fluid. Some evidence is given indicating that the resistance of the core is not a unique function of the saturation but depends upon the manner in which this saturation was achieved. Equipment and technique are discussed for measurement of resistivities in core plugs in which water saturation can be varied.

INTRODUCTION

A number of investigations[1-8] of the resistivity-saturation relationship for unconsolidated sands and consolidated core samples have been reported in the literature. According to most of these, $R_s = R_{100}S^{-2}$, where R_s = the resistivity of a formation at saturation S, and R_{100} = the resistivity of the formation at 100 per cent water saturation. Much of this work was done on unconsolidated sands desaturated by gas or oil. Henderson and Yuster[8] worked exclusively with dynamic systems, flowing oil or gas through consolidated cores. There is some doubt as to how well this reproduces static reservoir conditions. Jakosky and Hopper[3] considered also the case of consolidated core plugs, but the oil-water distribution in the emulsions which they used to saturate their cores is almost certainly different from that occurring in reservoirs. Recently Guyod[7] quotes the results of some Russian work which indicates that n may vary from 1.7 to 4.3. No experimental details of this work are available.

In connection with electric log interpretation it is important to know the value of the saturation exponent. For example, if in a given reservoir it is found that the resistivity is three times the resistivity observed when the reservoir is 100 per cent saturated with water, this fact would be interpreted as indicating a water saturation of 33 per cent if the saturation exponent were 1 and a water saturation of 64 per cent if the saturation exponent were 2.5.

EXPERIMENTAL METHOD

In the work to be described it was assumed that reservoir conditions are most nearly obtained when core plugs are desaturated by the capillary pressure technique referred to in numerous places in the literature, as for example, in Bruce and Welge's paper.[9] In this technique the core, saturated 100 per cent with brine, is placed in contact with a ceramic disc permeable to brine but not to the displacing medium for the displacement pressures used. Pressure is then applied to the displacing medium and brine forced out of the core through the ceramic disc. Fig. 1 shows the core plug in place in the cell in which resistivity and saturation measurements are made. Fig. 2 shows the schematic electrical diagram used to make resistivity measurements on the core plug. A four-electrode type circuit is used, employing a Hewlett-Packard model 400A, AC vacuum tube voltmeter. The 60-cycle AC current through the core is adjusted to 1 milliampere and measured by noting the voltage drop across the calibrated 100-ohm resistor. The voltages appearing at probes 1, 2, 3, and 4 are then successively measured. Voltage drops across the top, center, and bottom portions of the core are obtained by subtracting the voltages appearing at successive probes. This technique avoids any polarization or other high contact resistance phenomena which may develop at the current input electrodes. Resistances which may develop between the core and the probes, and which are small compared to the 1-megohm input impedance of the vacuum tube voltmeter will obviously not affect the measurements appreciably. Any very appreciable resistances which may develop at any of the probe wires are detected and allowed for by inserting a 1-megohm resistor in series with the voltage measuring probe. If the probe resistance is actually zero, the new voltage measured after insertion of the 1-megohm resistor will be approximately one-half of that previously measured, since the input impedance of the vacuum tube voltmeter is itself 1 megohm. If any appreciable probe resistance has developed, the new voltage is found to be appreciably greater than one-half of the previously measured voltage. Such probe resistances have been found to develop only occasionally and usually can be traced to poor connections between the core

[1] References given at end of paper.

Manuscript at office of Petroleum Branch, August 3, 1949. Paper presented at Branch Fall Meeting in San Antonio October 5-7, 1949.

and the probe, or to conditions prevailing at low core saturations where poor contact is established between the probe and the capillary water remaining in the core. These resistances develop often enough, however, to make the taking of this precaution very desirable.

Some additional specific precautions which should be observed in making measurements of this type are discussed below. In most of the work reported here nitrogen was used as a displacing medium, although a few runs were made using naphtha, kerosene, or crude oil samples. When gas is the displacing medium, it is extremely important to reduce to a minimum any fluctuations in temperature in the neighborhood of the displacement cell, since any appreciable temperature cycle will cause water to evaporate from the core and condense, usually upon the sides of the cell. Such evaporation and condensation phenomena lead to loss of water from the core due to means other than capillary displacement and hence to erroneous results. In the equipment used these temperature cycles were held to plus or minus 1°F.

It is also important to allow enough time to elapse after pressure is applied on the core to permit equilibrium conditions to be achieved. Some cores studied have not reached resistance equilibrium after periods as long as one month. Usually intervals of one or two weeks are required to reach equilibrium, even for cores of high permeability. The time required for equilibrium to be reached after the core is saturated and placed on the ceramic disc, but before pressure is applied, has also been found to be very long, often running from one to two days. Fig. 3 shows the way in which resistance varied as a function of time when desaturating pressure was applied to a typical core.

The question of a suitable contact material between the core and the ceramic disc and between the core and the top current electrode has not been solved to our complete satisfaction. The most suitable material tried to date has been moistened diatomaceous earth, which has performed considerably better from an electrical standpoint than has Kleenex, which has a tendency to dry out and pull away from the upper current contact. Diatomaceous earth, however, has disadvantages such as a tendency to clog the core and to reduce the accuracy of weight measurements.

Experience has taught that volumetric measurements, especially those obtained when gas is used as the displacing medium, are not so reliable as gravimetric or distillation estimates of core saturation. When a liquid rather than a gas is used as the desaturating fluid, volumetric measurements are considerably more reliable. It is felt that the most accurate technique, however, is to distill the desaturated core to obtain final saturation values, since the densities of the desaturating liquid and the water are usually so nearly the same that gravimetric methods fail if high precision is desired.

Care should be taken in cleaning the core or formation sample before beginning the saturation and resistivity measurements. The original salt as well as initial hydrocarbons should be removed from the core before it is saturated with brine and placed in the displacement cell.

An example of procedures used for making the measurements on consolidated cores is given below. Core plugs 2.0 cm in diameter by 2.0 cm long are usually used, although longer cores have been run. The core is cleaned by flowing acetone (to dissolve the hydrocarbons) followed by distilled water (to dissolve the salt) through the core for several hours. Fifty to 100 pore volumes of each are used. Four No. 22 B and S gauge wires are then twisted tightly about the core at equal intervals. Platinum, copper, and chromel wires have been used with about equal effectiveness. The core is then dried by baking at 220°F in an evacuated oven overnight, after which it is weighed. The core is saturated by placing in a chamber, which is then evacuated, and allowing de-aerated sodium chloride brine containing 5000 ppm chloride ions (to give a convenient conductivity) to enter slowly from below. (If bentonite is present or suspected in the core, it would be desirable to saturate with formation water.) When the core is covered by the brine, atmospheric pressure is admitted and the system allowed to stand for several hours. Tests made upon cores saturated in this manner using a Boyle's law type saturation

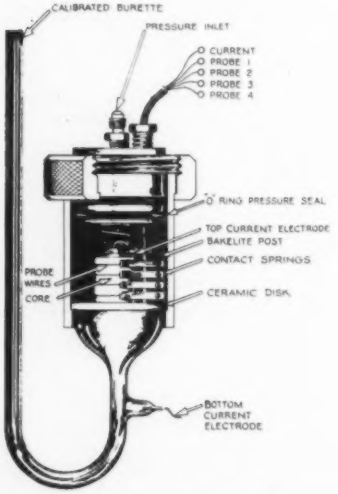

FIG. 1 — EXPERIMENTAL SET-UP SHOWING CORE IN PLACE IN CELL.

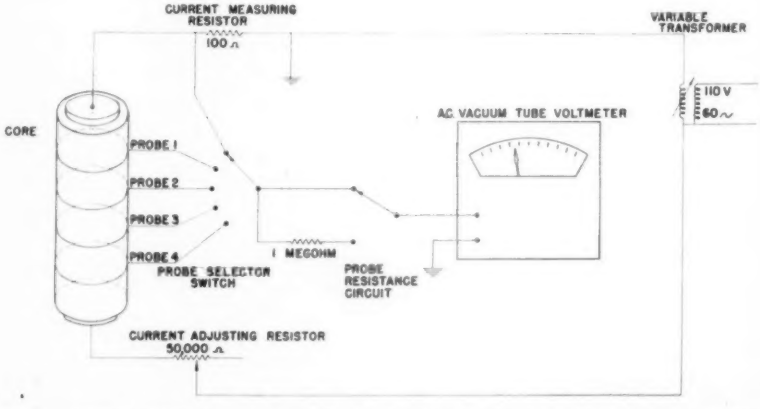

FIG. 2 — CIRCUIT DIAGRAM FOR RESISTIVITY MEASUREMENTS (THE PROBE RESISTANCE SWITCH IS NORMALLY IN THE POSITION SHOWN, THE ONE MEGOHM RESISTOR BEING INCLUDED ONLY WHEN CHECKING FOR PROBE RESISTANCE).

tester have indicated that this technique yields saturations ranging from 98 to 100 per cent. The saturated core is then weighed, placed on a porous disc saturated with the same brine and any excess water allowed to drain for about 24 hours. A negative or desaturating head of one-half inch of water (referred to the base of the core) is usually used. It is necessary to use this small negative head in order to insure that no excess water remains on the ceramic disc or on the sides of the core. The capillaries in most cores are small enough so that no interstitial water is removed by the procedure. A core thus *equilibrated* is then placed in the cell shown in Fig. 1. The cell is mounted in a constant temperature box maintained at 100°F plus or minus 1°F. Further equilibrium amounting to about 12 hours at the half inch negative head of water is allowed after assembling into the cell, until resistance measurements show no further change with time. Pressure is then applied to the desaturating fluid, usually nitrogen. In some cases the final desaturating pressure is applied immediately; in others, the pressure is increased stepwise. Resistance changes as a function of time for a given applied pressure are measured, and equilibrium conditions at a given pressure estimated from the constancy of this resistance value over an interval of several days. In many cases practical time limitations prevented equilibrium from being achieved. Simultaneous volumetric measurement of brine displaced is also made in order to estimate roughly the degree of saturation of the core. After resistance equilibrium is reached at the highest pressure used, the core is removed from the cell, and a final accurate saturation value obtained by weighing, distilling, or both. Since available evidence indicates that the saturation exponent, n, does not vary with saturation, determination of resistivity at two saturations determines the exponent.

Techniques for unconsolidated formation samples follow the above procedure as closely as the material permits. Unconsolidated samples containing bentonite are cleaned by flushing with acetone followed by formation water or a laboratory sample made up to match a formation water analysis. After the effluent water has the same resistivity as the incoming water, the sample saturated with the formation water is poured into the cell in which measurements are to be taken and allowed to equilibrate overnight with zero desaturating pressure (referred to the top of the sample. See Fig. 4). Using this technique there is no visual or other evidence to indicate stratification of the unconsolidated material occurring in the lucite cell. Desaturating pressure is then applied as before, and resistance and volumetric measurements are made. In this case gravimetric or distillation values of final saturation are not so important since considerably larger volumes of both sand sample and brine are involved and small volumetric errors do not affect the results so markedly. In some of the work reported here these final saturation checks were nevertheless made.

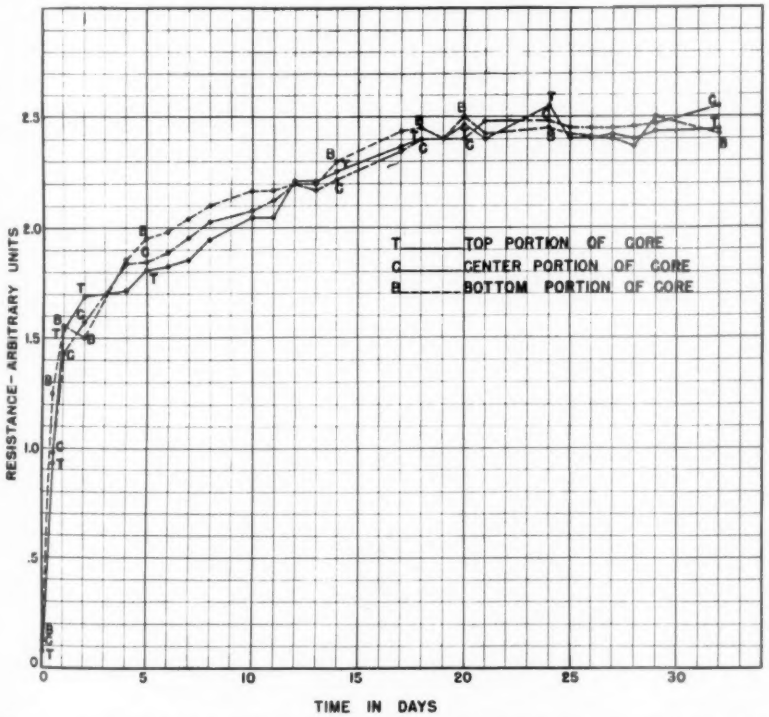

FIG. 3 — RESISTANCE AS A FUNCTION OF TIME FOR A CONSTANT DESATURATION PRESSURE OF 12 PSI.

CORE	= COTTON VALLEY SANDSTONE
POROSITY	= 18.6%
AIR PERMEABILITY	= 924 MD
DISPLACING MEDIUM	= N_2

RESULTS

In order to obtain the value of the saturation exponent, n, from measured values of the resistance and saturation, the resistance was plotted against the per cent saturation on log-log paper for each section of the core, and the saturation exponent obtained by measuring the slope of this line. Plotted saturation values, of course, represent

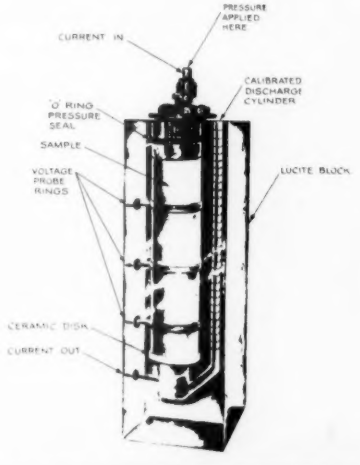

FIG. 4 — CELL FOR MAKING RESISTIVITY VS. SATURATION MEASUREMENTS ON UNCONSOLIDATED SAMPLES.

the average value for the entire core. The technique of measuring the resistance across several sections of the core permits estimates to be made of the degree of saturation at these sections, assuming that the core is homogeneous. Constancy of the saturation exponent for the various sections of the core was interpreted as indicating uniform saturation conditions throughout. It was considered necessary that this condition be fulfilled in order to obtain reliable values for n. In many cases cores which had reached apparent equilibrium at high desaturating pressures exhibited widely varying values for the saturation exponent in different parts of the core. The reason for this behavior is not completely clear, but there is some evidence to indicate that it may be due to (1) variation in properties of the core from point to point, (2) a small saturation gradient which appears to exist in some cases, with the most highly desaturated part of the core appearing closest to the disc. Whatever the cause these data were considered unreliable and have not been included in the results reported here.

Typical plots of resistance versus saturation are shown in Figs. 5, 6, and 7. Constant displacement pressures were applied during these runs and only the final points were brought to resistance equilibrium with time. Other runs on unconsolidated sands and consolidated sandstones indicate that the saturation exponents determined from points equilibrated at different saturations were the same. Hence subsequent exponents were determined using only the initial and final equilibrium points as shown in Fig. 7. Fig. 5 is typical of what we have considered to be reliable data obtained for clean, unconsolidated sands. The initial curvature in the plot of resistance versus saturation is believed to be associated with the rapid flow of brine through the core which occurs at this time. When pressure is applied slowly, these early deviations from linearity are much smaller or absent. Fig. 6 indicates a typical run with a bentonitic, unconsolidated sample. The data shown on this figure are not considered reliable, since the saturation exponent varies markedly and in a systematic manner from one part of the sample to another. The apparent trapping off of water in the upper section of the sample as illustrated in this run has been

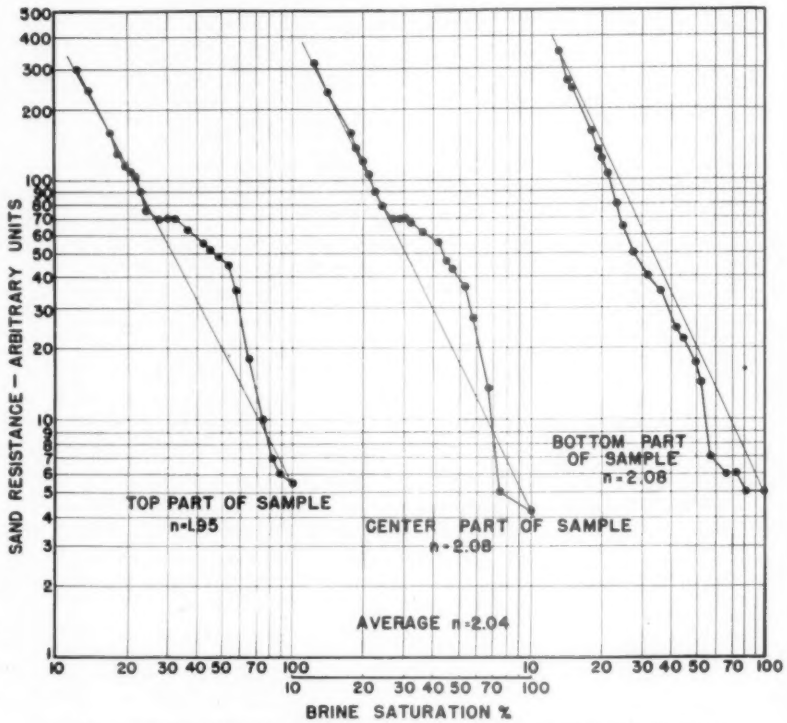

FIG. 5 — RESISTANCE AS A FUNCTION OF BRINE SATURATION FOR A CLEAN UNCONSOLIDATED SAND.

POROSITY = 37%
DISPLACING MEDIUM = N_2
CONSTANT DISPLACEMENT PRESSURE = 2 PSI

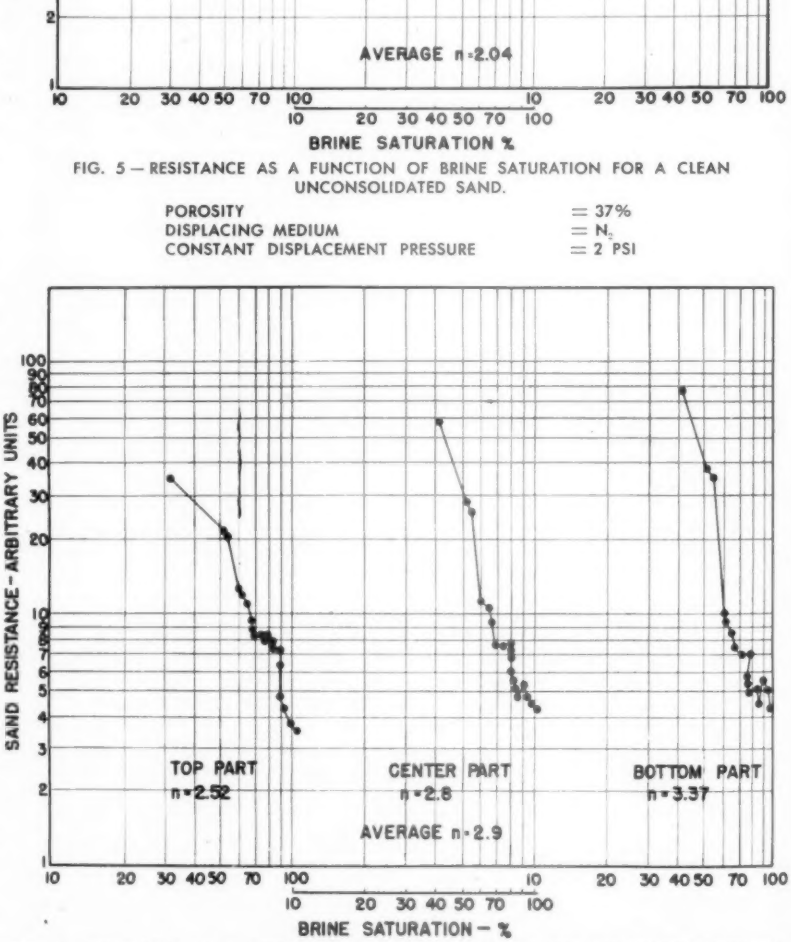

FIG. 6 — RESISTANCE AS A FUNCTION OF BRINE SATURATION FOR AN UNCONSOLIDATED SAMPLE CONTAINING ½% BENTONITE BY DRY WEIGHT.

DISPLACING MEDIUM = N_2
CONSTANT DISPLACEMENT PRESSURE = 3.6 PSI

TABLE I

Reproducibility of Results Obtained from Consolidated Samples
(Brine Displaced by N_2)

Core No.	Porosity %	Air Permeability (md)	Core Description	Run No.	Saturation Exponent, n. Top Part of Core	Center Part of Core	Bottom Part of Core	Average of Top, Center and Bottom	% Deviation of Average n.
1	18.5	266	Cotton Valley Sandstone	1	1.86	1.75	1.49	1.70	
1	18.5	266	Sandstone	2	1.39	1.69	1.70	1.59	14%
1	18.5	266	Sandstone	3	1.96	1.66	1.88	1.83	
2	19.9	416	Sandstone	1	1.53	1.45	1.43	1.47	
2	19.9	416	Sandstone	2	1.48	1.43	1.43	1.45	1%
3	20.2	736	Sandstone	1	2.24	2.02	1.84	2.03	
3	20.2	736	Sandstone	2	1.90	1.90	1.73	1.84	10%
4	22.5	770	Sandstone	1	1.87	1.67	1.55	1.70	
4	22.5	770	Sandstone	2	1.85	1.82	1.57	1.75	9%
4	22.5	770	Sandstone	3	1.85	1.90	1.82	1.86	
5	23.0	1450	Strawn Sandstone	1	1.15	1.21	1.15	1.17	1%
5	23.0	1450	Sandstone	2	1.11	1.08	1.34	1.18	
6	23.4	2190	Cotton Valley Sandstone	1	1.90	2.01	2.16	2.02	
6	23.4	2190	Sandstone	2	1.68	1.68	1.72	1.69	16%
6	23.4	2190	Sandstone	3	1.98	2.06	1.97	2.00	
6	23.4	2190	Sandstone	4	1.98	1.98	1.97	1.98	
7	18.6	924	Sandstone	1	2.05	1.94	1.82	1.94	12%
7	18.6	924	Sandstone	2	1.88	1.68	1.61	1.72	

observed frequently, particularly when the sample contains bentonite. Fig. 7 shows what is considered to be reliable data on a consolidated core of Cotton Valley sandstone. Resistivity measurements of three portions of the core were repeated on four runs which show good reproducibility.

The reproducibility of what we have considered average reliable data is shown in Table I, which gives the results of repeat runs on several cores of varying permeability. If the saturation exponents found for the top, center, and bottom sections of each core are averaged for each run, the data indicate differences in the average saturation exponent found on successive runs as great as 16 per cent.

The results obtained for unconsolidated samples, shown in Table II, have not been so consistent, fluctuations in the value of n as determined by repeat runs reaching values as high as 37 per cent. It is believed that this difficulty is at least partly associated with variations in packing the sample for the various runs.

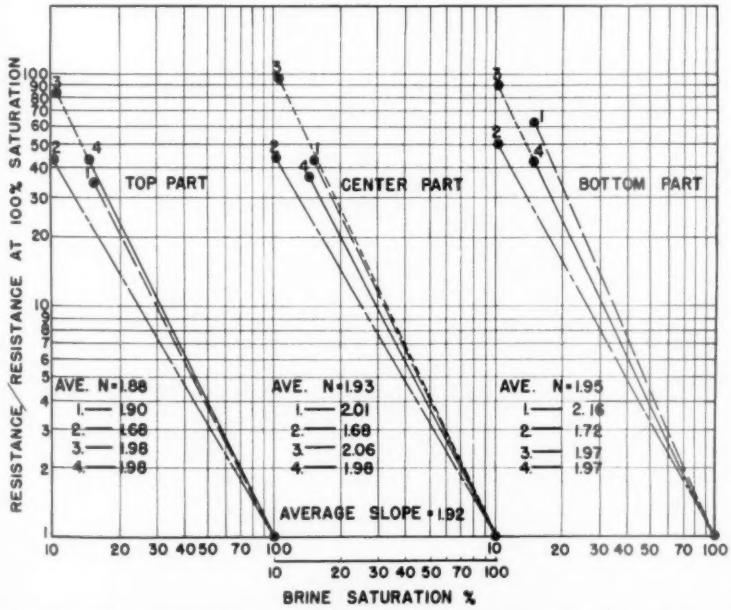

FIG. 7 — SEVERAL DETERMINATIONS OF RESISTANCE AS A FUNCTION OF BRINE SATURATION FOR A COTTON VALLEY SANDSTONE.
CONSTANT DISPLACEMENT PRESSURE = 12 PSI POROSITY = 23.4%
DISPLACING MEDIUM = N_2 AIR PERMEABILITY = 2190 MD

The range of observed values of n for both consolidated and unconsolidated samples has been from about one to two and one-half with some questionable data which indicate that n may take on values as high as three. For consolidated cores, n is usually less than two. To date it has not been possible in general to correlate the saturation exponent with permeability or porosity of the core. Fortunately, the saturation exponent does not appear to change as the interfacial tension between the brine and the desaturating medium varies. This is in agreement with theory, since for a static system variation in interfacial tension would be expected to vary the pressure at which a given saturation is reached, but not the geometrical arrangement of the water at that saturation. Table III gives some data on repeat runs on a core and an unconsolidated sample using nitrogen (interfacial tension 74 dynes/cm) and various liquid desaturants (interfacial tensions 30 to 35 dynes/cm). The variation in the saturation exponent with interfacial tension is not thought to be significant. This is very fortunate as it means that laboratory data obtained using a convenient desaturant, such as nitrogen or naphtha, may be used to represent reservoir conditions as far as interfacial tension is concerned.

The over-all question of how best to reproduce reservoir conditions in the laboratory as far as resistivity-saturation relationships are concerned is an important one, particularly since this work as well as that of other investigators[8] appears to indicate that the resistance-saturation relationship is not a unique one, but that the resistance at a given saturation depends on how that saturation was attained. This appears to be so even after what appear to be equilibrium conditions are reached, and saturation changes appear to have ceased. For example, the saturation exponent obtained from the capillary pressure technique is quite different from that obtained when a given saturation is arrived at as a result of dynamic flood-

ing experiments. Furthermore, the saturation exponents are different depending upon the order in which various materials are flowed through the core. For example, when careful resistivity measurements were made on a long Strawn sandstone outcrop having a porosity of 20 per cent, permeability of about 800 md, and which had been saturated with brine and flooded with naphtha, a saturation exponent of 1.19 was observed. An end point saturation was obtained from a material balance of the fluids flowing into and out of the core. When this core was then flooded with brine, a saturation exponent of 1.68 was observed. In each case an attempt to reach equilibrium was made, although it is not certain that this was achieved. Saturation exponent values observed using the capillary pressure technique when displacing brine are closer to the former than the latter. The difference between the static and dynamic results is probably due to viscous effects entering in the dynamic case.

The question of how to achieve a given saturation in order best to represent reservoir conditions is a very pertinent one and one which has not yet been answered. A completely satisfying answer, indeed, probably cannot be arrived at until a satisfactory solution to the problem of the accumulation and migration of hydrocarbons has been achieved. At the present time it appears that the capillary pressure technique offers the best hope of arriving at a fair representation of reservoir conditions, but as stated before, this is by no means certain. At least, the capillary pressure technique simulates reservoir conditions to the extent that it is a static system.

In order best to utilize data of this type in the interpretation of electric well logs it is important that a large statistical accumulation of the saturation exponents be available, measured on many types of formation and in many parts of the country. This is important particularly when attempts are made to interpret the logs of wildcat wells, which frequently are not cored. It was one of the aims of this paper to stimulate interest in the field so that other companies might perhaps undertake similar work, the results of which might be published.

In conclusion, acknowledgment should be made to the late Emil Kaye for early contributions to some of the techniques, to E. R. Brownscombe for many discussions and suggestions, and to John Cave for considerable experimental work in various stages of the investigation.

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TABLE II
Reproducibility of Results Obtained from Unconsolidated Samples
(Brine Displaced by N_2)

Sample Description	Run No.	Saturation Exponent, n: Top Part of Sample	Center Part of Sample	Bottom Part of Sample	Average of Top, Center, Cottom	Maximum % Deviation of Average n.
Graded Ottawa Silica Mortar Testing Sand	1	1.95	2.08	2.08	2.04	
Graded Ottawa Silica Mortar Testing Sand	2	2.05	[illegible]	2.12	2.04	37%
Graded Ottawa Silica Mortar Testing Sand	3	2.49	2.59	2.51	2.53	
Graded Ottawa Silica Mortar Testing Sand	4	1.81	[illegible]	1.69	1.75	
Same + 1/4% by dry weight of Aquagel	1	1.97	2.58	2.79	2.45	
Same + 1/4% by dry weight of Aquagel	2	2.52	2.80	3.37	2.90	17%

*These runs were made in the cell shown in Figure 3. Other runs shown in this table were made in a cell of slightly different design which permitted resistivity measurements o be made on three rather than two intervals in the sample.

TABLE III
Effect of Interfacial Tension on Saturation Exponent

Desaturating Fluid	Interfacial Tension (dynes-cm)	Core Description	n
Naphtha*	35	Smackover Lime 186 md, 12.9% Porosity	1.72
N_2*	74	Smackover Lime 186 md, 12.9% Porosity	1.76
Crude Oil	about 30	Unconsolidated Cockfield Sample, 48% Porosity	2.12
N_2	74	Unconsolidated Cockfield Sample, 48% Porosity	2.30
Naphtha	35	Unconsolidated Sand, 37% Porosity	2.11
N_2	74	Unconsolidated Sand, 37% Porosity	2.04
N_2	74	Unconsolidated Sand, 37% Porosity	2.17

*Equilibrated for four hours before pressure was applied. All other runs reported in this work were equilibrated for one to two days before pressure was applied.

MULTIPLE CONDENSED PHASES IN THE METHANE-DECANE-TETRALIN-BITUMEN SYSTEM

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ABSTRACT

As a part of a general investigation of the separation of bitumen from hydrocarbon mixtures a study was made of a restricted quaternary system composed of methane, decane, tetralin, and bitumen. The work was limited to a pressure of 8000 psi, a temperature of 220°F, and to a fixed relative proportion of decane, tetralin, and bitumen. The measurements permitted the determination of the distribution of these components in each of the fluid phases. It was not possible to distinguish a second liquid phase in the course of these measurements. Gas-liquid equilibrium "constants" of each of the components were found to vary markedly with the composition of the system while temperature and pressure remained fixed.

INTRODUCTION

The separation of bitumen from naturally occurring hydrocarbon mixtures has been of importance for a number of years in the production of petroleum, especially in the California area. The deposition of this material from crude oils was noted in earlier studies of the solubility of natural gas in crude oil.[1,2,3,4] Studies of the separation of bitumen from crude oils from the Greeley and Santa Fe Springs fields were carried out.[5,6] The behavior of these systems appeared complex and studies of two restricted ternary systems involving mixtures of n-pentane, tetralin, and bitumen,[7] and of decane, tetralin, and bitumen,[8] confirmed this belief. Reviews of the literature pertaining to the separation of bitumen from naturally occuring and refined hydrocarbons are available.[7,8]

The important effect of methane in the separation of bitumen from naturally occurring hydrocarbon mixtures was apparent from the earlier studies[2,3,4] and for that reason it appeared desirable to investigate a restricted quarternary system involving mixtures of methane, decane, tetralin, and bitumen; data concerning the behavior of mixtures of decane, tetralin, and bitumen having already been obtained.[8] This study was restricted to a pressure of 8000 psi,[a] a temperatue of 220°F, and fixed relative proportions of bitumen, decane, and tetralin. This composite constituent, hereinafter designated as the less volatile constituent, was made up of 0.0455 weight fraction bitumen, 0.0909 weight fraction decane, and 0.8636 weight fraction tetralin.

The experimental method involved bringing together mixtures of methane and the less volatile constituent in varying proportions in a constant volume container at the pressure and temperature indicated above. The composition of each of the phases was determined and from this the extent of the separation of bitumen was established.

MATERIALS

The bitumen used in this investigation was obtained from the same stocks employed in earlier studies.[7,8] The crude material from the North Coles Levee field was stored in the laboratory in a closed drum for a period of five years. Several samples from this stock were subjected to refining operations which were described earlier,[7] and every effort was made to follow the same procedure in all cases. It was necessary to prepare supplies of bitumen for this investigation at two rather widely different times. These materials have been identified as samples 1 and 2. The composition of the crude bitumen after it was washed with n-pentane at room temperature

[1] References are given at end of paper.
Manuscript received at office of Petroleum Branch August 3, 1949.

[a] All pressures cited are absolute.

is recorded in Table 1, together with the ultimate analysis of the two samples of refined bitumen. Some difference exists between the two refined samples of bitumen despite the fact that they were prepared by the same procedures.

The tetralin was obtained from a commercial source and was fractioned in a Hempel column[9]. After purification, the index of refraction was found to be 1.5380 for the D-lines of sodium at a temperature of 78°F. This may be compared with a published value of 1.53919 at 77°F.[10] The specific weight was 59.56 lb. per cu. ft. at 100°F.

The decane was obtained commercially and was purified by fractionation in a glass column with 30 plates at a reflux ratio of approximately 10 to 1. The purified material had an index of refraction of 1.4087 at 81°F as compared to the published value of 1.40986 for n-decane at 77°F.[11] Its specific weight was found to be 44.69 lb per cu ft at 100°F and atmospheric pressure.

PROCEDURES

The methods used in carrying out this study have already been described.[7] In principle, they involve the transfer of known quantities of the less volatile constituent and of methane into a weighing bomb.[8,11] The quantity of each of the constituents was determined from the corresponding change in weight of the bomb. The pressure was brought to a value of 8000 psi by introducing methane after the weighing bomb containing the less volatile constituent had been brought to a temperature of 220°F. The temperature was controlled by placing the bomb in an agitated air bath, the temperature of which was within 0.2° of 220°F. Equilibrium was obtained by oscillating the weighing bomb for a period of 2 hours. Methane was added as needed to keep the pressure at 8000 psi during the approach to equilibrium. The bomb was then placed in a centrifuge and upon rotation any separated bitumen was deposited as a firm coating on the walls of the container. The phases were then separated by withdrawing fluid from the top of the bomb through a valve while introducing mercury through the lower valve in order to maintain isobaric conditions. The composition of each of the displaced phases was determined by volumetric measurement of the separated methane and from information concerning the specific weight of the methane-free liquid collected and the quantity of bitumen present in this latter material. The quantity of bitumen was determined by pentane precipitation in accordance with procedures described earlier.[7] No effort was made to determine the quantities of methane, decane, and tetralin actually associated with the solid bitumen phase. However, from qualitative observation is appeared that the amounts of these components in the separated bitumen phase were very small.

EXPERIMENTAL RESULTS

To aid in the determination of the composition of decane-tetralin-bitumen mixtures the specific weights of mixtures of tetralin and decane and of mixtures of tetralin and bitumen were determined. From these measurements values of the partial specific volume of the bitumen in tetralin were established. It was assumed that the partial volume of the bitumen in the decane-tetralin mixtures would be substantially the same as in tetralin since the variation in the partial volume of the bitumen over a relatively wide range of weight fractions of

TABLE 1 — *Composition of Bitumen Samples*

Sample	Carbon	Hydrogen	Nitrogen	Sulfur	Ash	Mercury	Carbon-Hydrogen Ratio
Crude Bitumen, Pentane Washed	0.8625[a]	0.0842	0.0109	0.0118	0.0133		10.24
Refined Bitumen Sample 1	0.8417	0.0716	0.0080	0.0122	0.0097		11.76
Refined Bitumen Sample 2	0.8494	0.0752	0.0061	0.0227	0.0136	0.0041	11.30

[a]–Compositions are expressed as weight fractions.

TABLE 2 — *Specific Weight of Decane-Tetralin Mixtures at 100°F and Atmospheric Pressure*

Weight Fraction Tetralin	Specific Weight Lb/Cu. Ft.
0.0000	44.69
0.2492	47.74
0.4985	51.17
0.7485	55.11
1.0000	59.56

TABLE 3 — *Partial Specific Volume of Bitumen in Mixtures of Bitumen and Tetralin at 77°F. and Atmospheric Pressure*

Weight Fraction Bitumen	Partial Specific Volume Cu. Ft./Lb.
0.0000	0.013664
0.0500	0.013725
0.1000	0.013835
0.1500	0.013946
0.2000	0.014036

TABLE 4 — *Comparison of Analyses of Decane-Tetralin-Bitumen Mixtures*

Method	Decane	Tetralin	Bitumen
Gravimetric Preparation	0.8637[a]	0.0904	0.0458
Specific Weight Analysis[b]	0.8600	0.094	0.046

[a]—Composition expressed as weight fraction.
[b]—Compositions were determined from specific weight of mixtures.

TABLE 5 — *Comparison of Gravimetric and Refractive Index Methods of Determining Composition of the Liquid Phase*

Component	Analysis: Gravimetric	Analysis: Refractive Index
Methane[b]	0.131[a]	0.132
Decane	0.067	0.064
Tetralin	0.781	0.785
Bitumen	0.022	0.018
Methane[c]	0.130	0.135
Decane	0.073	0.076
Tetralin	0.784	0.777
Bitumen	0.013	0.013

[a]—Composition expressed as weight fraction.
[b]—Composition of system corresponds to 0.442 weight fraction methane. See Table 6.
[c]—Composition of system corresponds to 0.283 weight fraction methane. See Table 6.

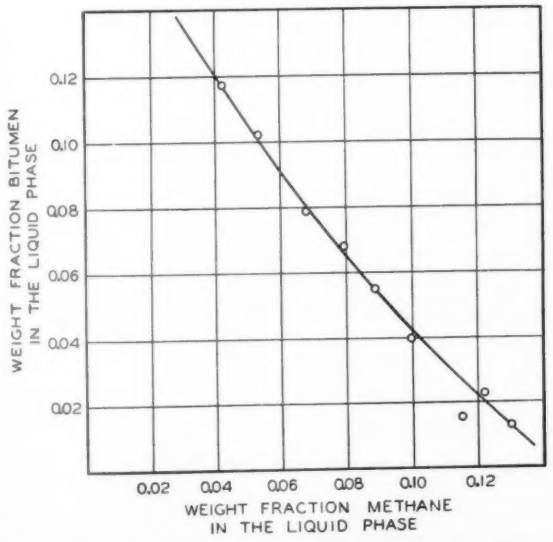

FIG. 1 — INFLUENCE OF DISSOLVED METHANE ON THE SOLUBILITY OF BITUMEN IN THE LIQUID PHASE AT 8000 PSI AND 220°F.

bitumen was only 2.7 per cent. Table 2 presents the specific weight of mixtures of decane and tetralin of varying composition at 100°F. and atmospheric pressure. The partial specific volume of bitumen used in the estimation of the composition of the methane-free liquids is recorded in Table 3. The weight fraction of bitumen in these methane-free liquids was determined in this case with an uncertainty of approximately 0.5 per cent of the quantity present. The uncertainty in the weight fraction of decane and tetralin was approximately 0.003. Table 4 compares the analysis of a mixture of tetralin, decane, and bitumen as determined from the data submitted in Tables 2 and 3 with values calculated from the gravimetric preparation of the sample. In addition the refractive index of the bitumen-free decane-tetralin mixtures recovered from the gas phase was determined and a satisfactory agreement between the specific weight and refractive index techniques was obtained as is shown in Table 5, which presents results for two different states.

The work reported in this discussion involves eight measurements with bitumen sample 1 and ten measurements with bitumen sample 2, the weight fraction of the bitumen separated being determined for the eighteen cases. The weight fractions of the system represented by the liquid, gas, and solid phases were established at two states for bitumen sample 1 and for the ten states investigated with bitumen sample 2. The compositions of the coexisting phases were determined for only two states in the case of bitumen sample 1 and for the ten states involving sample 2. The latter sample was investigated in much greater detail because of a need for such measurements found during the studies with bitumen sample 1. The less complete data for bitumen sample 1 are included since the results are directly applicable to the over-all study. In a number of instances where direct analyses were not available the composition of the liquid phase was ascertained by difference between the over-all composition of the system and the weight and compositions of the gas and bitumen phases. The fact that under the conditions investigated a second liquid phase was not observed made this possible.

Table 6 presents the detailed results of all of the measurements made. The two parts of the table relate respectively to bitumen samples 1 and 2. Values are given of the weight fraction of the components in each of the phases and in the system as a whole. The weight fraction of the total bitumen which separated out as a solid is presented.

Fig. 1 shows the influence of methane in the liquid phase upon the weight fraction of bitumen sample 2 in the liquid phase of the restricted methane-decane-tetralin-bitumen system at 8000 psi and 220°F. These results indicate a relatively rapid reduction in the weight fraction of dissolved bitumen with an increase in the weight fraction of methane in the liquid phase.

Fig. 2 shows the weight fractions of the system contributed by the gas, liquid, and solid bitumen phases as related to the weight fraction of methane in the system as a whole. The bubble-point and dew-point compositions have been indicated. The dew point in this instance is the state at which the liquid phase disappears on increasing the weight fraction of methane, even though solid phase is present. The weight fraction of the solid bitumen phase is shown on the very much enlarged scale indicated on the right-hand side of the figure. The

maximum quantity of bitumen separated was less than 0.025 weight fraction of the system. The data for the two bitumen samples agree well in regard to the weight fraction of liquid and gas phases. The experimental points indicated in Fig. 2 include all the data that were available. The complex behavior of the solid phase was shown by both bitumen samples. However, a marked difference in this behavior was found at weight fractions of methane below 0.45. The weight fraction methane in the system as a whole has been used as the independent variable in this and subsequent figures because the investigation was limited to constant temperature and pressure and to a restricted system involving fixed relative proportions of decane, tetralin and bitumen, the only variation being in the weight fraction of methane. The weight fraction of the total bitumen present which separated as a solid phase is shown in Fig. 3 as a function of the weight fraction of methane in the system as a whole. Again the marked difference in behavior at low weight fractions of methane is indicated for the two samples of bitumen. At present, the cause for this difference can be ascribed only to the difference in the composition of the bitumen as indicated in Table 1.

Throughout this work it was assumed that a negligible quantity of bitumen was present in the gas phase. This was substantiated by the relatively light color of the tetralin and decane obtained from the gas phase upon its withdrawal from the weighing bomb. In accordance with this assumption the weight fraction of the bitumen separated is indicated in Fig. 3 as unity at the dew point.

The composition of the liquid phase is shown in Fig. 4. The weight fraction of methane in the liquid phase increased rapidly to bubble point which was at approximately 0.1 weight fraction methane in the system and continued to increase gradually until there was approximately 0.3 weight fraction methane in the system as a whole. At higher weight fractions of methane in the system its weight fraction in the liquid phase gradually decreased until at dew point the small amount of liquid remaining contained little more than 0.04 weight fraction methane.

The weight fraction of decane in the liquid phase decreased gradually and that of tetralin remained substantially constant as the weight fraction of methane in the system increased. The decreasing solubility of methane in the liquid phase might be expected from the decreasing ratio of decane to tetralin in the phase. The minimum in the weight fraction of bitumen occurring at a weight fraction methane in the system as a whole of approximately 0.3 corresponds to the maximum values of bitumen separated as indicated in Fig. 2 and 3. The logarithmic ordinate scales used in both Fig. 2 and 4 serve to magnify the changes relating to bitumen as compared to those for the other components. Because methane in the liquid phase is effective as a precipitant for bitumen, the maxi-

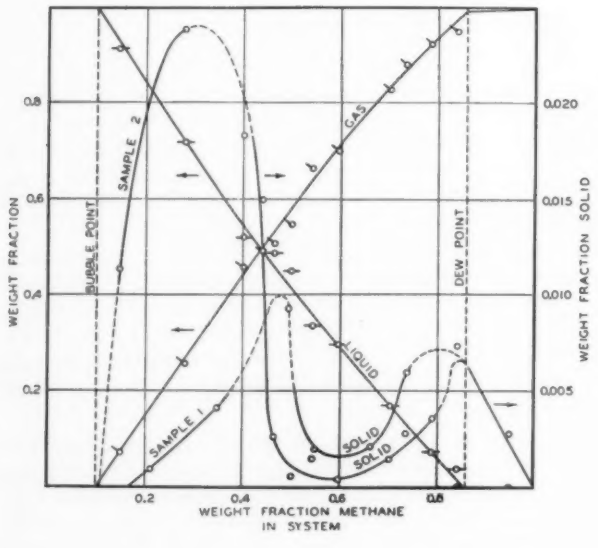

FIG. 2 — DISTRIBUTION OF THE PHASES AT 8000 PSI AND 220°F.

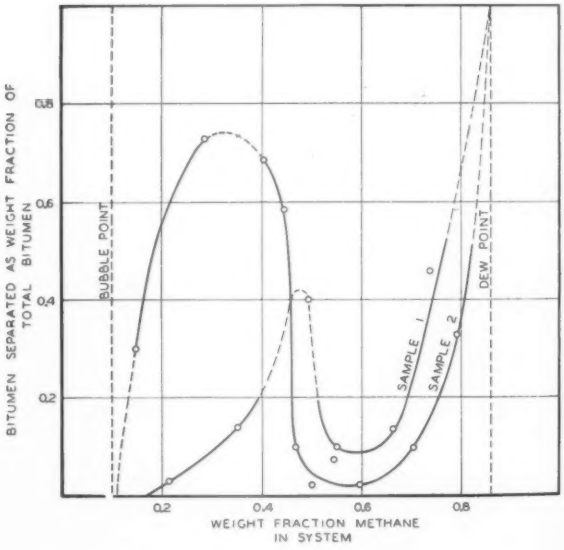

FIG. 3 — BITUMEN SEPARATED AS A SOLID PHASE AT 8000 PSI AND 220°F EXPRESSED AS WEIGHT FRACTION OF TOTAL BITUMEN.

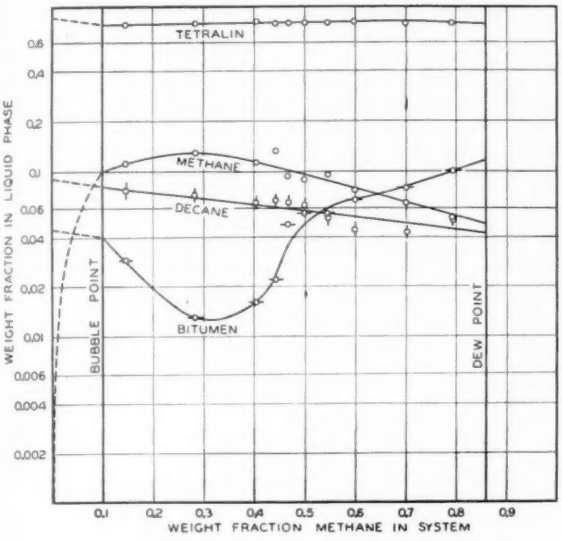

FIG. 4—COMPOSITION OF THE LIQUID PHASE AT 8000 PSI AND 220°F.

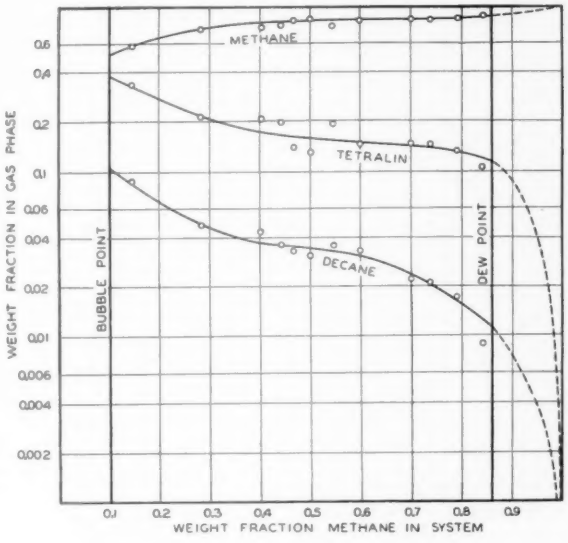

FIG. 5 — COMPOSITION OF THE GAS PHASE AT 8000 PSI AND 220°F.

mum in its weight fraction could well account for the minimum in the bitumen weight fraction.

The weight fraction of methane in the gas phase, as shown in Fig. 5, increased gradually with the weight fraction of methane in the system as a whole, the change being more rapid at the lower weight fractions of methane. Conversely the weight fractions of tetralin and decane both decreased. Data for both bitumen samples were included in Fig. 4 and 5 and no marked divergence appeared. At states richer in methane than dew point, the weight fractions in the gas phase have been indicated as linear functions of the increasing weight fraction of methane in the system.

Table 7 presents values of the gas-liquid equilibrium constants for methane, decane, and tetralin as calculated from the phase compositions corresponding to the curves of Fig. 4 and 5. For this purpose a value of 1500 was taken as the molecular weight of the bitumen. This was an average of values obtained from the freezing point lowerings of benzene, carbon tetrachloride, and tetralin as solvents for the bitumen. Relatively large uncertainties were encountered in these measurements.

TABLE 6 — *Characteristics of the Restricted Methane-Decane-Tetralin-Bitumen System at 8000 PSI and 220°F*

Weight Fraction Methane in System	Weight Fraction Bitumen Separated	Weight Fraction of Phase in System			Compositions of Phases[c]						
					Gas Phase			Liquid Phase			
		Solid	Liquid	Gas	Methane	Decane	Tetralin	Methane	Decane	Tetralin	Bitumen
0.211[a]	0.027	0.0010									
0.350	0.140	0.0042									
0.493	0.399	0.0093									
0.550	0.099	0.0020									
0.663	0.137	0.0021									
0.737	0.459	0.0060	0.113	0.881	0.835	0.021	0.144	0.013	0.049	0.876	0.062
0.842	1.000	0.0078	0.041	0.951	0.885	0.009	0.106				
0.949	1.000	0.0028									
0.147[b]	0.290	0.0114	0.914	0.074	0.581	0.088	0.331	0.113	0.077	0.780	0.029
0.283	0.727	0.0239	0.720	0.256	0.737	0.048	0.215	0.130	0.073	0.784	0.013
0.403	0.685	0.0183	0.522	0.459	0.750	0.043	0.207	0.113	0.065	0.806	0.016
0.442	0.585	0.0150	0.493	0.492	0.766	0.036	0.198	0.131	0.067	0.781	0.022
0.466	0.101	0.0026	0.489	0.508	0.827	0.033	0.140	0.094	0.065	0.794	0.048
0.500	0.021	0.0005	0.451	0.549	0.839	0.031	0.130	0.088	0.063	0.793	0.056
0.544	0.073	0.0015	0.336	0.663	0.771	0.036	0.193	0.096	0.052	0.796	0.056
0.598	0.022	0.0005	0.299	0.700	0.821	0.033	0.145	0.078	0.044	0.811	0.068
0.703	0.097	0.0014	0.171	0.828	0.835	0.024	0.141	0.068	0.043	0.809	0.082
0.791	0.329	0.0036	0.073	0.924	0.852	0.017	0.132	0.053	0.051	0.796	1.000

[a]—Prepared from Bitumen Sample 1.
[b]—Prepared from Bitumen Sample 2.
[c]—All phase compositions are expressed as weight fractions.

TABLE 7 — *Equilibrium Constants for Methane, Decane, and Tetralin in Restricted Quaternary System at 8000 PSI and 220°F.*

Weight Fraction Methane in System	Methane	Decane	Tetralin
0.10	1.83	0.452	0.175
0.20	1.74	0.294	0.114
0.30	1.73	0.204	0.0798
0.40	1.84	0.158	0.0590
0.50	2.03	0.142	0.0480
0.60	2.29	0.130	0.0399
0.70	2.55	0.0963	0.0349
0.80	2.88	0.0617	0.0290
0.85	2.98	0.0484	0.0256

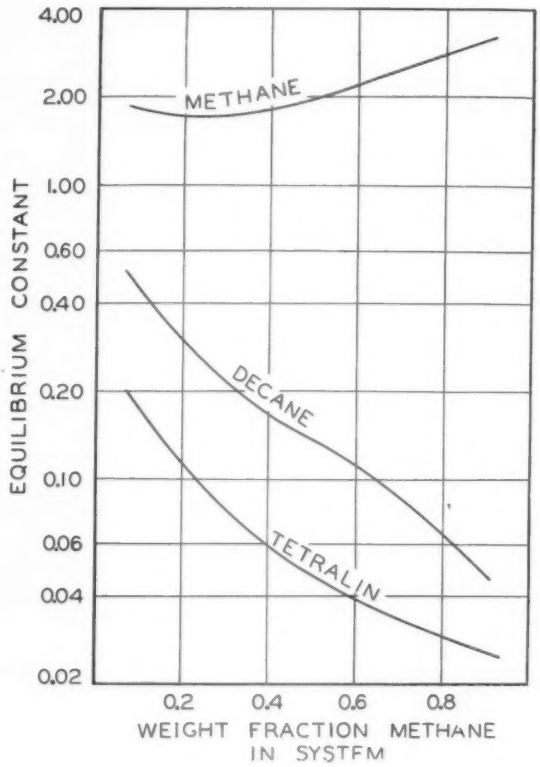

FIG. 6 — EQUILIBRIUM CONSTANTS FOR METHANE, DECANE, AND TETRALIN IN THE RESTRICTED QUATERNARY SYSTEM AT 8000 PSI AND 220°F.

Values varying between 1100 and 1800 were found with different samples of the bitumen and different solvents. In each case the measurements were carried out at several weight fractions of bitumen and the results were extrapolated to infinite dilution. Fortunately, variations in the molecular weight of the bitumen do not markedly influence the values of the equilibrium constants reported in Table 7. Fig. 6 shows the value of the equilibrium constants for methane, decane, and tetralin in relation to the weight fraction of methane in the system. The data contained in Fig. 6 and Table 7 afford an indication of the influence of the composition of the system upon equilibrium constants for three of the components at the chosen pressure and temperature. The rather marked decrease in the equilibrium "constants" of decane and tetraline with increase in the weight fraction of methane apparently results from progressively larger deviations from ideal solution behavior in the liquid phase as dew point is approached.

The experimental results presented indicate the complexity of behavior that may be expected in hydrocarbon systems involving components of relatively high molecular weight. However, the limited data obtained leave much to be desired in the way of completeness, relating only to the characteristics of a restricted quaternary system at a single temperature and pressure.

ACKNOWLEDGMENT

This paper is a contribution from American Petroleum Institute Research Project 37 located at the California Institute of Technology. The assistance of N. D. Zimmerman, H. H. Reamer, and J. D. Yanak in connection with the experimental program is acknowledged.

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FUNDAMENTAL FORCES INVOLVED IN THE USE OF OIL WELL PACKERS

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INTRODUCTION

The successful use of oil well packers requires, in part, an understanding of the pressures which exist at the packer in various applications and an understanding of the characteristics of the various types of packers. It is with these pressures, the resultant forces, and the characteristics of packers, that this paper is primarily concerned.

An oil well packer may be defined as a mechanical device for blocking the passage of fluids in an annular space. In the more usual case, the annular space is that between the tubing or drill pipe in a well and the casing, and packers which block such an annular space are broadly referred to as casing packers. In the other case, the annular space is that between the tubing or drill pipe and the walls of an open hole, and packers for blocking this space are generally called formation packers. While the hydraulics involved are essentially the same for casing and formation packers, a greater variety of conditions are encountered in the use of casing packers and only casing packers will be discussed.

After a packer has been set and a pressure seal effected between tubing and casing, the packer is comparable to a piston in a cylinder. Pressures acting upon a piston result in forces which will move the piston unless some means is provided to prevent such movement. In the same manner, pressures acting upon a packer will move the packer unless there is present a sufficiently great restraining force.

PACKER CLASSIFICATIONS

Packers may be classified according to the pressure conditions under which they are capable of blocking the annular space between tubing and casing. Fig. 1 shows schematically two types of packers in common use. These packers are capable of blocking the annular space against the passage of fluids under a differential pressure of significant magnitude only when the pressure in the annular space above the packing element is greater than the pressure below. It may be seen that in Fig. 1-a, slips with teeth which bite into the casing and prevent downward movement are provided. In Fig. 1-b, an anchor prevents downward movement. In each case, there is only the tubing to prevent upward movement when differential pressures act to move the packers upwardly. Packers which hold only a significant differential pressure acting downwardly have been in use since the early days of the oil industry and will hereafter be referred to as conventional type packers.

In many packer applications operating conditions will result in differential pressures across the packer which will at times act to move the packer upwardly, and at other times, act to move the packer downwardly. For these applications, designs are available which will block the annular space and resist movement in either direction. Fig. 2-a shows schematically a packer of this type which is designed to be run into a well and set, and removed when desired by merely pulling the tubing. It will be noted that two sets of slips are provided—one set above the packing element to prevent upward movement, and another set below the packing element to prevent downward movement. This packer is built around a mandrel which is essentially a part of the tubing, and which is free to move longitudinally within certain limits through the set packer. Fig. 2-b shows schematically a permanent type packer which is capable of holding pressures from either direction. Here again, two sets of slips are provided to prevent movement of the packer. This packer is designed to become virtually a part of the casing when set and it is made of drillable material so that it may be drilled out when its removal is desired. The seal nipple shown effects a pressure seal between the tubing and the packer. This seal nipple is a part of the the tubing, and the nipple and tubing may be withdrawn from the well without disturbing the packer. It should be noted that these figures are not representative of all available packers which are designed to hold pressures from both above and below. Packers which resist movement in either direction will hereafter be referred to as universal type packers.

There is a third type of packer in general use and this type is designed to block the passage of fluids when the pressure below the packing element is greater than that above. This type is provided with slips which prevent upward movement of the packer and is somewhat similar to a conventional type packer run upside-down. Packers designed to hold pressure only from below are made in a variety of designs and are usually owned and operated by service companies.

Manuscript received at office of Petroleum Branch November 22, 1948. Paper presented at Joint Meeting of the Texas Sections in Austin, Texas, December 16-17, 1948.

There are, then, three types of packers to be considered—conventional packers designed to hold a differential pressure acting downwardly; universal packers designed to hold pressure from above or below; and special packers designed to hold only an upwardly acting differential pressure.

FACTORS AFFECTING PACKERS

Fig. 3 shows schematically the essential elements which must be considered in evaluating the pressures and forces which occur in the use of conventional and universal type packers. In the case of conventional packers, Support 2 should be regarded as fixed against downward movement. In the case of universal packers, Support 1 should be regarded as fixed against upward movement, and Support 2 again regarded as fixed against downward movement. In each case, the mandrel is permitted at least a limited upward movement without disturbing the packer setting.

Factors which must be considered include the tubing load required to compress the packing element, the changes in tubing load as well conditions change, pressures above and below the packer, the unbalanced valve area on packers having circulating valves, and the unbalanced area inside the packing element and outside the tubing on valveless packers.

It is convenient in nearly all cases to evaluate the pressures and forces on the tubing separately from the pressures and forces on the packer, and this will be done in all cases considered in this discussion. With few exceptions, the mandrel which passes through conventional and universal type packers has an inside diameter substantially equal to the inside diameter of the tubing upon which the packer is run, and an outside diameter equal to or greater than that of the tubing. Since any pressure which acts to move the packer upwardly will also act to move the mandrel upwardly, the outside diameter of a full opening mandrel in a conventional packer is not a factor, and it may be considered as having an outside diameter equal to that of the tubing.

Pressure Force on Packer

Pressures from above or below conventional packers may be regarded as acting over an annular area from the outside of the tubing to the inside of the casing tending to move the packer up or down. Annular areas for tubing-casing combinations in common use are tabulated in Table I.

The pressure force on a conventional packer may be expressed as

$$F_p = p(\pi/4)\ [(\text{casing ID})^2 - (\text{nominal tubing OD})^2] \quad (1)$$

$$= p\ A_p$$

where

F_p = pressure force on the packer, lbs.
p = pressure acting to move packer, psi.
A_p = annular area — tubing OD to casing ID, sq. in.

Unbalanced Valve Area

Most of the packers in common use have circulating valves which may be opened without disturbing the packer setting. Some of these valves are pressure balanced and some are not. The unbalanced valve area now considered is that area which tends to keep the valve closed under a differential pressure from above. Referring to Fig. 3, it will be seen that a differential pressure acting downwardly acts over an annular area from the outside diameter of the valve to the outside diameter of the tubing tending to keep the valve closed. Some packers in common use have sufficiently great valve areas to prevent opening of the valve and pulling of the packer under conditions where a high differential pressure acting downwardly exists. Instances have occurred where several hours were spent unsuccessfully in attempting to unseat and pull a packer under these conditions. It is sometimes necessary to at least partially fill the tubing or otherwise reduce the differential pressure across the packer before it can be pulled.

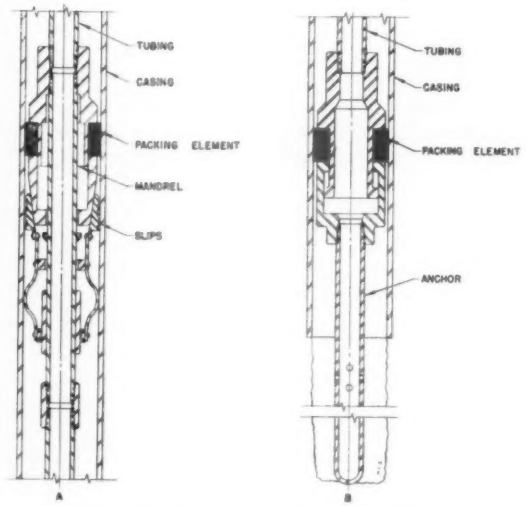

FIG. 1 — CONVENTIONAL TYPE PACKERS

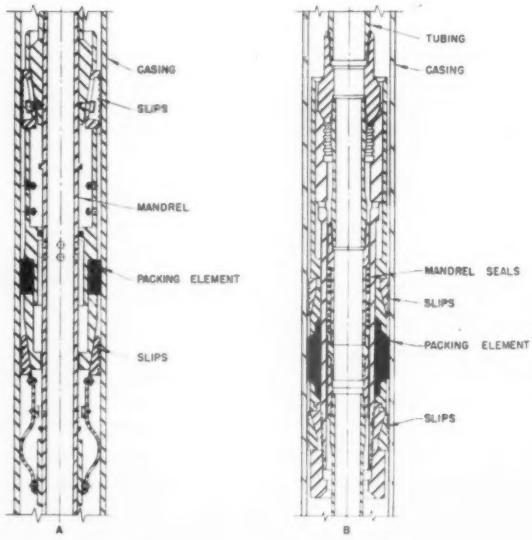

FIG. 2 — UNIVERSAL TYPE PACKERS

Mandrel in Universal Type Packers

The mandrel in universal packers is usually sealed inside the packer and is sometimes larger than the nominal outside diameter of the tubing. Since the tubing is to be considered separately, it is convenient to regard the annular area of the mandrel from the outside diameter of the tubing to the maximum diameter of the packer sealed by the mandrel as a separate and distinct area. Pressure acting over this area will act to move the mandrel up or down.

TABLE I

Annular Area Exclusive of Tubing Over Which Pressure Acts to Move Full Opening Conventional Packers Upwardly or Downwardly

API Casing Size	*API Tubing Size*	*Annular Area - Sq. In.*
5½ in. - 15.5 lb	2 in.	16.1
5½ in. - 17 lb	2 in.	15.6
5½ in. - 20 lb	2 in.	14.8
5½ in. - 23 lb	2 in.	14.0
7 in. - 23 lb	2½ in.	25.3
7 in. - 26 lb	2½ in.	24.4
7 in. - 29 lb	2½ in.	23.5
7 in. - 32 lb	2½ in.	22.7

Annular Area = Area of nominal ID of casing – area of OD of tubing

Cross Sectional Area of Tubing Entering into Buoyancy Calculations

2 in. API tubing, $2\frac{3}{8}$ in. OD, 1.995 in. ID – 1.31 sq in.

2½ in. API tubing, $2\frac{7}{8}$ in. OD, 2.441 in. ID – 1.81 sq in.

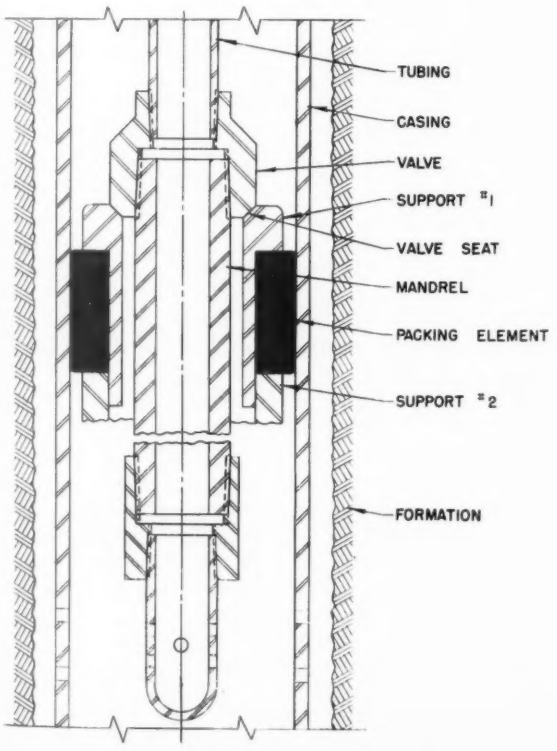

FIG. 3—ELEMENTS TO BE CONSIDERED IN EVALUATING THE PRESSURES AND FORCES WHICH OCCUR IN THE USE OF CONVENTIONAL AND UNIVERSAL TYPE PACKERS

FACTORS AFFECTING TUBING LOAD ON PACKER

Friction of Tubing Against Casing

Tubing in longitudinal compression is supported horizontally by the casing, and when tubing is subjected to excessive compression loading the distortion usually results in "corkscrewed" tubing. This indicates that tubing in compression is probably in a gentle spiral bearing against the casing. Since tubing load must almost always be applied to compress the packing element, a portion of the length of the tubing must be supported horizontally by the casing. This condition results in friction of an indeterminate amount which resists movement of the tubing. The amount of this friction varies with the straightness of the hole and other factors and very little experimental data are available on the subject. In one instance, 16,000 lb. was slacked off at the surface before shear pins designed to shear at 8,000 lb. were sheared. In this case the packer containing the shear pins was run on 2½ in. upset tubing and set at 10,270 ft in 7-in. OD casing. This is considered unusual, but there is always a definite possibility, because of friction of the tubing against the casing, or the resistance of a tubing coupling to movement past a casing joint, that all the weight slacked off at the surface will not reach the packer.

Buoyancy

When any pipe is lowered into fluid in a well, the fluid exerts a buoyant force which supports a portion of the weight of the pipe. The extent of this buoyant force may be determined with negligible error in the case of tubing by neglecting the couplings and obtaining the product of the pressure within the fluid column at the lower end of the tubing string and the cross sectional area of the walls of the tubing. Unless there is a considerable amount of tubing beneath the packer, buoyancy calculations may be further simplified without significant error by disregarding the tubing beneath the packer and assuming that the tubing only extends to setting depth. Thus, the pressure value to use in determining the effect of buoyancy may usually be taken as the fluid pressure existing in the annular space below the packer. The buoyant force tending to raise the tubing may be expressed as

$$F_b = p(\pi/4)\ [(\text{nominal tubing OD})^2 - (\text{nominal tubing ID})^2] = p\,A_t \quad (2)$$

where

p = pressure below packer, psi.

F_b = buoyant force on tubing, lbs.

A_t = annular area — tubing ID to tubing OD, sq. in.

It must be clearly understood, however, that no buoyant force can be exerted on the pipe unless the fluid has an opportunity to act over the annular area of the pipe. Fluid about a pipe suspended vertically has no vertical component and can exert no buoyant force. (There is a very small buoyant force on the couplings and upsets but it is strictly negligible.) Reference to Fig. 3 will show that there can be no buoyant force on the tubing with fluid in the annulus above the packer when there is no fluid or pressure within the tubing. There

is no opportunity for the fluid to act over the annular area of the tubing.

The effect of buoyancy complicates the determination of forces at a packer. In the case of a string of tubing freely suspended in a hole filled with fluid, where the fluid has access to and fills the interior of the tubing, the lower portion of the tubing is in longitudinal buoyant compression. This results simply from the pressure at the lower end of the tubing acting over the annular area of the tubing to exert an upward (buoyant) force on the tubing at that point. If this buoyant force is reduced or removed, a corresponding tubing force is transferred to and must be supported by the packer. Thus, the force which the tubing exerts on a packer will vary with the pressure below the packer.

The weight of the tubing initially buoyed by fluid may be considered a separate and distinct force. It acts downwardly, and at the time a packer is set it is exactly counteracted by the buoyant force on the tubing.

Pressure Change

John P. DeHetre[1] has developed equations for determining the change in casing load at the well head for changing pressures and temperatures about the casing. These equations are also applicable to the change in tubing load on a packer when pressures and temperatures about the tubing change, provided that the tubing does not move at the surface or at the packer. DeHetre's equation for the effect of pressure change is

$$P = 0.0434W\triangle pD/t \qquad (3)$$

where

P = change in load, lbs
W = nominal pipe weight, lb per ft
$\triangle p$ = average net pressure change on free pipe, psi
D = pipe OD, in.
t = pipe wall thickness, in.

The effect of pressure change about the tubing is frequently significant in the use of packers. It is easily possible to build up sufficient pressure in the tubing when using universal type packers to lift all tubing weight from the packer, and this pressure, which also acts to increase the buoyant force on the tubing, may be great enough to lift the mandrel entirely out of the packer with resultant passage of fluid to the space above the packer. This pressure effect also makes more difficult the holding of a differential pressure below a conventional packer without damaging the tubing when the intial required tubing load is placed on the packer. It results in changing tubing loads on the packer in all cases where the pressures about the tubing are changed from the conditions existing when the packer was set.

Fig. 4 is a graphical solution of Equation (3). Tubing friction, and the effect of spiraling of the tubing inside the casing are neglected. Internal pressure increase results in decreased tubing load on the packer.

Temperature Change

DeHetre's equation for the effect of temperature change is

$$P = 58.2W\triangle T \qquad (4)$$

where

P = change in load, lb
W = nominal pipe weight, lb per ft
$\triangle T$ = average temperature change of free pipe, °F

The effect of temperature change of the tubing is also frequently significant in the use of packers. The difficulty here lies in determining the average temperature changes that may occur. However, the direction of the expected temperature change will usually be known and it will usually be possible to make an estimate of the degree of change. An allowance can then be made in the amount of tubing weight set on the packer to care for the expected temperature change.

Fig. 5 is a graphical solution of Equation (4). Tubing friction, and the effect of spiraling of the tubing inside the casing are neglected. Temperature increase results in increased tubing load on the packer.

DETERMINING NET TUBING LOAD ON PACKER

Analyzing a packer application is simplified by considering the tubing separately. In nearly all cases the mandrel on which a packer is built is simply a continuation of the tubing, and anything larger than the nominal size of the tubing on which the packer is run may be considered a part of the packer.

In practically all conventional and universal packer installations at least some tubing weight on the packer is essential or desired. For this reason it is convenient to regard downward tubing forces, and any change which tends to increase the downward forces, as positive. Negative forces will then include all upward forces, and all changes which act to decrease the tubing load on the packer. These forces and changes of force are then combined to determine the net tubing load on the packer. In the examples given later, the positive and negative tubing forces are tabulated separately for clarity.

NET FORCE ON PACKER

It is characteristic of practically all conventional packers that tubing weight must be applied to expand the packing element into sealing contact with the casing. It is further characteristic of these packers that the packing element strives to return to its unset shape and will do so if sufficient tubing weight is removed. For this reason such packers must always* have sufficient tubing load applied to them if a seal is to be maintained. The amount of tubing load required, or what might be called the minimum setting load, varies with the make and size of packer.

If a conventional packer is to remain in place, the downward forces must at least equal the upward force. If the seal is to be maintained, the downward forces must exceed the upward forces by the minimum setting load, and the downward forces must include a tubing load at least equal to the minimum setting load.

[1] "Casing Landing Practice", by John P. DeHetre, API Drilling and Production Practice, 1946.

* There is an exception. Where the differential pressure acting downwardly is great, little or no tubing load is necessary to maintain packing element compression. This may be understood by reference to Fig. 3. It will be noted that there is an annular area existing between the inside diameter of the packing element and the outside diameter of the tubing. In most of the available conventional packers, this area is in the neighborhood of one-third of the annular area between the tubing and casing. A differential pressure from above acts over this area to aid in maintaining packing element compression. Also, after varying periods and usage, many packing elements assume a permanent set and exert much less tendency to return to their unset shapes. These characteristics, if considered, should be regarded as safety factors.

The major downward force on a packer is usually the pressure force resulting from pressure above acting downwardly over the annular area of Equation (1). The net tubing load is the only other downward force on a packer.

Since the tubing load is to be determined separately, the only upward force on a packer is the pressure force resulting from pressure below the packer acting over the annular area of Equation (1).

An upward force not considered is that exerted on the slips, or on an anchor. Where the downward forces exceed the upward, the excess is carried by slips or an anchor.

EXAMPLES

Some examples of packer applications will emphasize many salient features which must be considered in the use of packers. Assume the following conditions:

Conventional type packer with circulating valve

API Casing — 7 in., 29 lb. N-80, at setting depth, 6.14 in. ID

API Tubing — 2⅞ in. OD x 2.441 in. ID, 6.5 lb/ft. EUE. Grade J-55

Setting Depth — 10,000 ft

Mud in Well — 9.6 lb/gal; pressure gradient—0.5 psi/ft

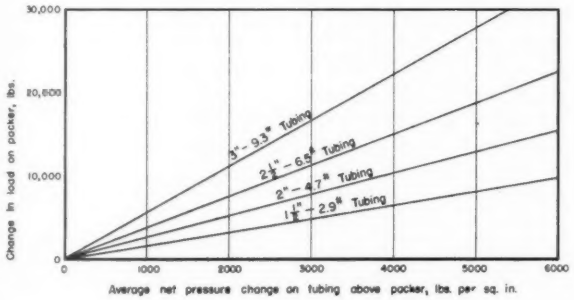

FIG. 4 — EFFECT OF PRESSURE CHANGE ON TUBING LOAD ON PACKER

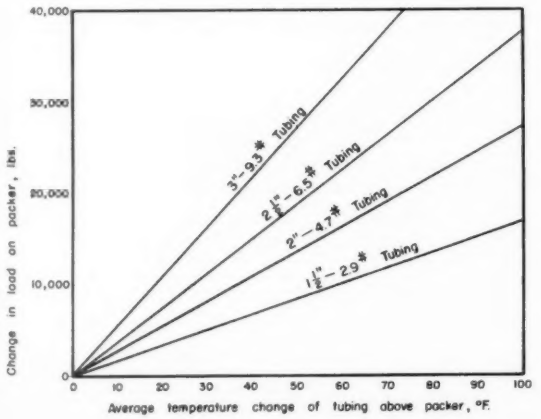

FIG. 5 — EFFECT OF TEMPERATURE CHANGE ON TUBING LOAD ON PACKER

Minimum tubing weight to compress packing element—10,000 lb

Unbalanced valve area — 10.8 sq in.

Annular Area, Tubing to Casing: $A_p = 23.5$ sq in., from Table I

Annular Area of Tubing: $A_t = 1.81$ sq in., from Table I

When the packer has been run to 10,000 ft, there is all about the packer a pressure of 5,000 psi. The buoyant force on the tubing is

$$F = pA_t$$
$$= (5{,}000)(1.81)$$
$$= 9{,}050 \text{ lb}$$

When the packer is set with a tubing load of 10,000 lb, the net tubing load on the packer may be determined in the following manner:

Positive Tubing Forces

1. Tubing setting load	10,000 lb
2. Weight of tubing initially buoyed by fluid	9,050
Total Positive Forces	19,050 lb

Negative Tubing Forces

1. Buoyant force on tubing	9,050 lb

Net Tubing Load on Packer

(Positive Forces - Negative Forces)
$= 19{,}050 - 9{,}050$
$= 10{,}000$ lb

The forces on the packer may be tabulated in the following manner:

Downward Forces on Packer

1. Pressure force on packer: $pA_p = (5000)(23.5) =$	117,500 lb
2. Net tubing load on packer, from above	10,000
Total Downward Forces	127,500 lb

Upward Force on Packer

$pA_p = (5000)(23.5) =$ 117,500 lb

It is seen that the downward forces exceed the upward forces by 10,000 lb, and that the downward forces include a tubing load of 10,000 lb. Since this is the amount of excess downward force, and tubing force, to maintain compression of the packing element, conditions are satisfactory at this point for this type of packer.

Effect of Swabbing

Next assume that the casing has been perforated a few feet below the packer setting and that when the tubing is swabbed to bring the well in, the well will not flow. The tubing is consequently swabbed to bottom. Pressure conditions and forces are now considerably different. It will be noted that there is no longer a column of fluid in the tubing to exert an upward force on the packer and tubing and hence the upward forces are now zero. Prior to swabbing, the column of fluid outside the tubing was balanced by a column of fluid inside the tubing, but with the removal of fluid from the tubing, the annular space above the packer exerts a pressure tending to collapse the tubing. This decrease in internal tubing pressure results in an additional downward force on the packer. The average internal pressure decrease is 5,000/2 or

2,500 psi. The wall thickness of the tubing is (2.875 – 2.441) /2 or 0.217 in. The additional downward force is

$$P = 0.0434\ W\ p\ D/t$$
$$= (0.0434)\ (6.5)\ (2,500)\ (2.875)\ /\ (0.217)$$
$$= 9,350\ \text{lb}$$

The net tubing load on the packer may be determined in the following manner:

Positive Tubing Forces

1. Tubing setting load	10,000 lb
2. Weight of tubing initially buoyed by fluid	9,050
3. Increase due to pressure change	9,350
Total Positive Forces	28,400 lb

Negative Tubing Forces

None

Net Tubing Load on Packer

28,400 lb.

The forces on the packer may be tabulated in the following manner:

Downward Forces on Packer

1. Pressure force on packer: $pA_p = (5000)\ (23.5) =$	117,500 lb
2. Net tubing load on packer, from above	28,400
	145,900 lb

Upward Force on Packer

None

This is a considerable downward force. The example chosen is not an unusual one. Swabbing a well to bottom with the tubing set on a packer and with mud in the annulus above the packer is a common occurrence, and in many cases the depth is deeper and the mud heavier so that larger downward forces exist.

The 10,000 lb tubing weight slacked off at the surface in setting the packer represents only 6.8 per cent of the total downward force on the packer. It is thus evident that the weight with which a packer is set is a relatively insignificant portion of the load carried by a packer when a well is swabbed down. Had it been decided to set the packer with say 20,000 lb to make certain that the packing element was adequately expanded, irrespective of frictional or other forces, the additional weight would have been less than 7 per cent of the total load on the packer. Since the setting load is such a small percentage of the total load to which packers are often subjected, there are few valid arguments favoring the setting of packers with the minimum possible setting weight. It is the effect of high setting weights upon the tubing and the disadvantages of tubing in compression that must be considered, and not the effect upon the packer.

Fig. 1-a shows an anchor type packer which depends upon an anchor pipe to prevent downward movement of the packer. This example shows that where an anchor is used to support a packer, it may be subjected to a large longitudinal compression load and it must therefore have sufficient column strength to prevent failure.

It should be noted that when a conventional packer is swabbed down on, it is fulfilling a purpose for which it is particularly suited; i.e., holding downwardly acting forces and pressures. If a failure occurs, it is usually due to the inadequacy of the packer and not to the application.

Effect of Unbalanced Valve Area

To pull the packer of this example loose and remove it from the well without first pumping fluid into the tubing, it is necessary to exert a sufficient pull on the tubing to support the entire weight of the tubing, and to open the circulating valve against the pressure above the packer. The tubing weighs 65,000 lbs., and the force required to open the valve is (10.8) x (5,000) or 54,000 lb, for a total required pull at the surface of 119,000 lb. The tubing in such a well as this example would usually be grade J-55 which has a minimum yield strength listed at 99,660 lb. In this case, as in many similar ones, it would be advisable to fill the tubing at least partially before attempting to unseat the packer.

Conventional packers without circulating valves sometimes offer a similar problem which requires at least partially filling the tubing before the packer can be unseated.

Effect of Gas Wells

Again using the data of the example, assume now that the formation just below the packer contains gas at a static pressure of 4,500 psi and that the shut in surface pressure is 3,500 psi. The average external pressure on the tubing is still 2,500 psi. The average internal pressure is now (3,500 + 4,500) /2 or 4,000 psi. The decrease in the force exerted by the tubing on the packer because of this average internal pressure increase of 1,500 psi is 5,700 lb from Fig. 4.

The net tubing load on the packer in this application is determined as follows:

Positive Tubing Forces

1. Tubing setting load	10,000 lb
2. Weight of tubing initially buoyed by fluid	9,050
Total Positive Forces	19,050

Negative Tubing Forces

1. Buoyant force on tubing. (4,500) (1.81) =	8,150 lb
2. Decrease due to pressure change	5,700
Total Negative Forces	13,850 lb

Net Tubing Load on Packer

19,050 – 13,850 = 5,200 lb

The forces on the packer may be tabulated in the following manner:

Downward Forces on Packer

1. Pressure force on packer: (5000) (23.5) =	117,500 lb
2. Net tubing load on packer	5,200
	122,700 lb

Upward Force on Packer

$pA_p = (4500)\ (23.5)$ = 105,700 lb

Net Downward Force on Packer

122,700 – 105,700 = 17,000 lb

In this case, the total downward forces exceed the upward forces by a comfortable margin. However, the net tubing load

on the packing element, which is the primary force maintaining packing element compression, is only 5,200 lb. It would be advisable in an installation such as this to increase the tubing setting load by some 5,000 lb to insure maintenance of packing element compression.

If the packer in the above example had been set a considerable distance above the producing formation, the pressure of the mud acting downwardly would be decreased significantly while the pressure of the gas acting upwardly would be decreased only slightly. This could result in insufficient downward force to maintain packing element compression or to prevent upward movement, and it is likely that such a packer installation would fail.

It sometimes happens that a liner of considerable length is set in a well and the well completed on a packer which is set in the casing above the liner. The pressure conditions which will exist in such an installation of a conventional packer should be carefully investigated to see if the downward forces will exceed the upward forces by a sufficient amount to maintain the compression of the packing element.

Bottom hole chokes and regulators are sometimes run inside the tubing. Such devices will usually result in an average pressure inside the tubing which is less than that when the packer was set, and thus tend to place a greater tubing load on the packer. However, the chokes offer a piston effect due to the differential pressure across the choke and this tends to lift the tubing. The cooling effect of the expanding gas above the chokes may result in a significant average temperature drop within the tubing and the effect of this may be to raise the tubing from the packer. Unless proper care is exercised in this type of installation, the downward forces may not be sufficient to maintain compression of the packing element and prevent upward movement of the packer, and the packer may fail in its purpose.

Effect of Upwardly Acting Differential Pressure on Conventional Packers

Assume that it is desired to hold a differential pressure of 1,000 psi underneath the conventional packer of the example in an operation such as acidizing the formation below. Assume further that the acid used has a pressure gradient of 0.5 psi per foot and that pumping the acid down the tubing will lower the temperature of the tubing an average of 30°F. The only means available for holding a differential pressure below a conventional packer is tubing weight, and the amount of tubing weight which is required when friction is neglected will be determined. The pressure within the acid at the packer is 5,000 psi due to the fluid column, plus 1,000 psi pump pressure applied at the surface for a total pressure at the packer of 6,000 psi.

The upward pressure force on the packer will be:

$$pA_p = (6000)\ (23.5) = 141{,}000 \text{ lb}$$

The downward pressure force on the packer will remain at 117,500 lb. Since the total downward forces must exceed the upward pressure force by 10,000 lb, the net tubing load on the packer when acidizing must be

$$(141{,}000 + 10{,}000) - 117{,}500 = 33{,}500 \text{ lb}$$

The tubing setting load applied prior to acidizing will decrease when pressure is applied to the tubing. The decrease in load for 1,000 psi average increase in internal pressure is 3,700 lb from Fig. 4.

The tubing setting load will also be decreased when the tubing is cooled by the acid pumped down. This decrease in load for a 30° F temperature decrease is 11,300 lb from Fig. 5.

The tubing setting load required may be determined in the following manner:

Positive Tubing Forces

1. Tubing setting load	X
2. Weight of tubing initially buoyed by fluid	9,050
Total Positive Forces	(X + 9,050) lb

Negative Tubing Forces

1. Buoyant force on tubing, (6000) (1.81)	=	10,900 lb
2. Decrease due to pressure change		3,700
3. Decrease due to temperature change		11,300
Total Negative Forces		25,900

The net tubing load on the packer as determined above is 33,500 lb

Then

Net tubing load on packer = (Positive tubing forces) − (Negative Tubing Forces)

$$33{,}500 = (X + 9{,}050) - 25{,}900$$

$$X = 50{,}350$$

In practice, some assistance is received from friction, so it probably would not be necessary to slack off as much as 50,000 lb tubing weight onto the packer to maintain 1,000 psi differential pressure under the packer. Further, when pressure must be applied to the tubing as in this example, it is almost always possible to apply pressure to the casing also, so that there would actually be little or no differential pressure across the packer. This example explains the difficulties experienced with conventional packer leakage when substantially equivalent fluid columns are in the tubing and casing and pressure is applied only to the tubing.

In many dually completed wells, changing pressure differentials across the packer result in large upward and downward forces. If a conventional packer is used to isolate the two producing zones, there may not be sufficient tubing weight available to maintain the packer setting against upwardly acting differential pressure, and this will result in intercommunication between the two zones.

Upwardly Acting Differential Pressure on Universal Type Packers

Universal type packers are suitable for holding pressure differentials acting upwardly, but care must be taken to place sufficient tubing weight on the packer, or otherwise arrange the installation, so that the mandrel will not be moved upwardly out of the packer when pressure and temperature changes occur. If pressure and temperature changes of considerable magnitude are expected, it is advisable to analyze the resultant effect upon the tubing. Attention must be paid the particular design to be used, as in some designs the mandrel diameter and sealing arrangement permit pressure from above and below to exert forces tending to move the mandrel which are independent of and in addition to the various forces affecting tubing load. Difficulties have been experienced in using universal type packers simply because changed well conditions

caused an upward movement of the mandrel with resultant leakage about the mandrel.

Effect of Squeeze Cementing Pressures

Destructive pressures sometimes occur when using packers, as in squeeze cementing. In this application, the pressures below the packer are often very high. There is a column of cement slurry which usually has a pressure gradient of about 0.84 psi/ft, plus high pressures applied to the tubing. This pressure is sometimes transmitted upwardly outside the casing and acts to collapse the casing above the packer. The casing in the above example has a published minimum collapse pressure of 6,370 psi. If it is assumed that the tubing is completely filled with cement slurry and that a squeeze pressure of 5,000 psi is applied, the pressure below the packer is (0.84) (10,000) psi plus 5,000 psi, or 13,400 psi. The pressure above the packer is (0.5) (10,000), or 5,000 psi. If channels exist which permit the application of the pressure below the packer to the outside of the casing above the packer, there is a net differential pressure of 8,400 psi tending to collapse the casing. Since there is danger of casing collapse when the minimum collapse pressure is exceeded, there is a good possibility that the casing in this example would have collapsed above the packer. Collapsing the casing above a packer is ordinarily very expensive to remedy, and is usually avoided in a case such as this by applying sufficient internal pressure to the casing to counteract the collapsing pressure.

CONCLUSIONS

The type of packer required for a given installation may be determined from an analysis of the conditions to be met. The amount of tubing load necessary to maintain the installation when expected pressure and temperature changes occur may be determined by analysis. When the proper type of packer is set with the proper tubing load for the application, chances for a successful installation are enhanced.

ACKNOWLEDGMENT

The author is indebted to The Atlantic Ref. Co. for permission to release this paper and wishes to express his appreciation for the aid recevied from various members of the engineering staff of the company. ★ ★ ★

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